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ESN INFORMATION BULLETIN

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ACOUSTICS

MATERIALS

MATHEMATICS

MECHANICS

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NEWS, NOTES, AND ABSTRACTS

ACOUSTICS

Psychoacoustics Research at the Applied Psychology Unit, Medical Research Council, Cambridge, U.K.

by David Feit, Liaison Scientist for Acoustics and Mechanics in Europe and the Middle East for the Office of Naval Research European Office. Dr. Feit is on leave from the David Taylor Research Center, Bethesda, Maryland, where he is a research scientist in the Ship Acoustics Department.

Introduction

Dr. Roy Patterson, at the Applied Psychology Unit (APU), Medical Research Council, Cambridge, U.K., for the past 15 years, heads five researchers who are investigating various aspects of psychoacoustics. At the time of my visit, Dr. Larry Feth was completing a 6-month sabbatical from Ohio State University during which he worked with Patterson and his group.

Auditory Warning Signals

I first met Patterson at the spring 1989 meeting of the British Institute of Acoustics where he had organized and chaired a special session on Warning Signals and Behavioral Response. Although psychoacoustics is a subject far removed from my own particular field of specialization, I think it is appropriate to report on the psychoacoustics research at the APU because of its possible relevance to bioacoustic signal classification, a subject that is of interest to the Office of Naval Research, Cognitive and Neural Sciences Division.

Patterson and his group have been working on auditory warning signals for about 10 years. The U.K. Civil Aviation Authority originally asked APU to investigate pilots' complaints about the intrusive effects of warning sounds in the flight decks of civil aircraft (see *ESN* 35-10 [1981]). The pilots' complaints were threefold--the warning sounds were confusing, too loud, and there were too many. A review revealed that the complaints were well founded.

Research on this topic at the APU has focused on four issues:

1. What is the appropriate sound level for auditory warning signals?

2. What are the appropriate spectral characteristics that allow for discrimination of a specific warning signal from other members of the set?

3. What are the short- and long-term temporal characteristics making the signal attention-getting, distinctive and memorable?

4. Based on the results of Nos. 1, 2, and 3, what should the design be of a prototype ergonomic warning system?

Patterson's recent paper (Patterson, 1989) summarizes these efforts and ends with design guidelines for warning signals that could be used in trains, planes, or hospitals. According to Patterson these signals, "...present their message with reasonable urgency and promptly fall back to permit vital communication, returning to interrupt forcefully only if there is reason to believe that the condition is not receiving sufficient attention."

Auditory Sensation Processing

During my visit to the APU, I was also briefed on the current work of the group that is related to auditory sensation processing (ASP). Patterson understands audition to be the totality of signal processing needed to recognize individual words in speech or notes in music when these occur in an unambiguous context.

Without getting into the debate about the separability of sensations and perceptions, Patterson is attempting to model the early stages of audition, which he views as the minimum set of processes required for a sensation to occur. The objective of the project is to develop an ASP computer model that will apply a set of transformations or processes that will take as input a complex sound, operate on its time history, and convert it into a form that would be a reasonable representation of what is heard in the sound. Because of computer size limitations available to Patterson, the ASP model is monaural and no localization module has been included within the software package.

The computer program is structured into four modules--two used in the simulation of peripheral processing, and two for central processing.

In the first stage of peripheral processing, the sound is spectrally analyzed by a flexible membrane (representing the basilar membrane) in contact with a strip of needle-like cells (the outer hair cells). According to Patterson, the equations of motion representing this system is still to be determined, and in their absence the spectral analysis simulation is performed by a bank of auditory filters. This set converts the sound wave into a surface showing the output of the filters, representing the motion of the basilar membrane and outer hair cells as a function of time.

The next stage involves the action of the cochlea wherein the inner hair cells convert the previous output into neural transmitter which sets the firing of the sensory neurons attached to the hair cells. Physiological data indicate that in the cochlear response, there is a significant compression and a rapid adaption to level changes in the data. This is modeled as a logarithmic compressor and adaptive threshold generator. The resulting surface again plotted as a function of frequency and time is called a "cochleogram" and is a representation of the output of peripheral auditory processing that provides the input to a central auditory processing module.

The modeling of the central processing is different from that of the peripheral processing. The modules for the latter summarize auditory physiology as is currently known; whereas, the central processing module models the link between peripheral physiology and human perception, an area that is much less understood and therefore highly hypothetical. With this as background, the two major ingredients introduced by Patterson at this stage are temporal integration and stabilization. In his ASP model, these are achieved by using the larger peaks in the cochleogram to trigger a "quantized" temporal integration process. The quasi-periodic sounds are then integrated over the periodic cycle, thus allowing the truly periodic response to accumulate and the aperiodic information to gradually fade away. The result is a stabilized auditory image that Patterson claims is a reasonable representation of the sensation that we hear.

Patterson is packaging the software so that other investigators can make use of the ASP model in their own research.

European Community Cooperative Programs

Patterson is directing a European Strategic Program for Research and Development in Information Technology project BRA-207, which is called Auditory Connectionist Technology for Speech. This project represents a cooperative effort among scientists from France, Italy, Portugal, and the U.K.

Conclusion

Although I cannot comment on the quality of the research because of my lack of knowledge in the field, I was certainly impressed by the enthusiasm and clarity with which Patterson presented his work. It also appears to me that it would be useful to expose the ASP model to some characteristic sonar signals to perhaps gain more insight in characterizing the bioacoustical response of sonar operators.

Reference

R. Patterson, "Guidelines for the Design of Auditory Warning Sounds," Proceedings of the British Institute of Acoustics 1989 Spring Conference, Vol. II, Part 5, pp. 17-24, (1989).

Acoustics Research at the Technical University, Berlin

by David Feit

Introduction

On a recent visit to Berlin, I met with Professor Manfred Heckl, the Head of the Institute for Technical Acoustics (Institute), one of the many institutes of the Technical University of Berlin. Professor Heckl has directed the Institute since 1972, when he succeeded Professor Lothar Cremer. There are two other professorial members of the Institute with whom I was not able to visit. Professors J. Gruber and M. Hubert specialize in psychological and physiological acoustics, and noise control, respectively. Professor Hubert recently retired.

Currently, there are 12 doctoral students. Contrary to current U.S. experience where a large portion of the graduate students in the sciences are foreign nationals, there are only three students at the Institute who are not German nationals. According to Heckl, the explanation for the difference is that in the Federal Republic of Germany, the graduate students are remunerated comparable to what they would receive in industry.

Dry Friction Damping

During a tour of the laboratory facilities, Heckl described some of the projects being pursued by students under his tutelage. In one project, they are examining the role of damping in the dynamic response of an automobile engine. As a prelude to vibration measurements on an actual engine block, U. Schober (a student) has made measurements on the damping introduced by dry friction in several different configurations. In one, he considers a freely suspended single degree of freedom system made up of a single metal disk of a specified mass sandwiched between two identical disks under a specified preload and driven end on. The system is modeled as two masses connected by a spring and a dissipative element. With a knowledge of the masses, the resonance frequency determines the spring constant, and the Q (sharpness of the resonance) determines the dissipation introduced by the dry friction. The stiffness and damping introduced by the dry friction can then be determined as a function of the preload and a measure of the surface roughness at the interfaces. Similar measurements are being made on a different arrangement that consists of a cylinder that is press fit against another cylinder with varying amounts of internal pressure.

In a related project, the fundamental mechanics of the generation of interface stiffness by the surface roughness is being examined by another student, M. Yang. In his experiment, Yang uses a solid steel block that sits on another steel surface; the block is driven longitudinally by a shaker while the response in the same direction is monitored by several accelerometers oriented to measure acceleration in the same direction as the shaker force. Here the stiffness induced at the interface varies with the amplitude of excitation and static load. They have observed that as the amplitude increases, the stiffness decreases and the damping increases. When the entire system is subjected to a constant motion, the stiffness also decreases. After the experimental program is completed, the interface stiffness will be analyzed using as a basis the theory developed by R.D. Mindlin. The problem to be analyzed is that of a sphere resting on an elastic half space and driven by a load in the direction parallel to the surface of the plane. Yang also is conducting an experiment where he is measuring the transverse stiffness presented by spheres resting on a plane. The latter is being used to corroborate the theory developed by Mindlin and Deresiewics (Mindlin, 1953).

Rolling Wheel Noise Generation Mechanisms

There are several projects related to rolling noise generation. One in particular is looking at the basic mechanisms involved in tire noise generation. The student has made measurements of the acceleration signals on a steel-belted radial tire as it rotates and has related specific segments of the signal with distinct mechanisms of wave propagation in the tire; these are forward and backward traveling flexural and longitudinal waves. The basic contribution here is a new type of modeling of the excitation force acting on the tire and its correlation with measured portions of the acceleration signal.

Another project involves the simulation of railway noise induced by the wheel-rail interaction. A paper on this subject was presented by Professor Heckl at a workshop on railway noise scheduled at the Institute for October 10-11, 1989. For conference details, contact:

M. Heckl
Institut fur Technische Akustik
Einstufer 25
D-1000 Berlin 10

Chaos in Acoustical Systems

I also discussed with Dr. Klaus Brod work that is being done on deterministic chaos applied to acoustical problems. The interest in this subject arose out of a project in which a student was looking at the noise generated by a dot matrix printer. The student began by suspending paper that was maintained in tension by weights and excited by a noncontacting driver. The sound radiated by the paper was measured and some very unexpected results reminiscent of chaos; e.g., period doubling, were obtained for certain combinations of amplitude and frequency of excitation. The results have lent themselves to analysis by approaches used by investigators dealing with other manifestations of chaos such as the Lyapunov spectrum and averaging method. According to Brod, he has also been investigating simulating the response of a Helmholtz resonator with sharp lips at the opening. This presumably also shows evidence of a chaos type response.

Technical Facilities

I also viewed the various standard test facilities used for acoustical testing. The Institute has a reverberation chamber that has a volume of 200 cubic meters, and an anechoic room of 1,070 cubic meters. Lothar Cremer designed the anechoic treatment and it is made up of foam-like absorber material of various sizes held in place and suspended by wires at the walls of the room. When I saw it, the room was set up for an experiment in psychoacoustics involving spatial localization of sound sources by human observers (listeners).

Summary

Many of us in the U.S. are very much aware of Heckl's work through the book on structure-borne noise that he has written with Cremer (Cremer and Heckl, 1973), and is now being published in its third edition. The work

being done at the Institute is of the highest quality and continues to provide fundamental information on some of the most significant issues that arise in the structural dynamics aspects of acoustics; e.g., the role of dry friction in structural damping. We all look forward to the conclusion of current studies because they will provide us with a significantly better understanding of friction damping.

References

Cremer, L., M. Heckl, and E.E. Ungar, "Structure-Borne Sound," (Springer-Verlag, New York, 1973).

Mindlin, R.D, and H. Deresiewics, "Elastic Spheres in Contact Under Varying Oblique Forces," J. Appl. Mech., 20, 1953, pp. 327.

MATERIALS

The Materials Revolution Through the 90's--Powders, Metal Matrix Composites, and Magnetics

by Michael J. Koczak, the Liaison Scientist for Materials for the Office of Naval Research European Office. Dr. Koczak is on sabbatical leave from Drexel University, Philadelphia, Pennsylvania, where he is a Professor of Materials Engineering.

Introduction

The Seventh International Conference, sponsored by the BNF Metals Technology Centre, was held on July 3-5, 1989, at St. Catherine's College, Oxford, U.K. The conference was divided into session topics that included: Requirements and Applications, Process Technology, Powders and Magnetics, and Metal Matrix Composites. The applications of these materials were highlighted in terms of government, industrial, and academic research activity with the major emphasis on the utilization of powder processed structural and magnetic systems as well as metal matrix composites. This article will highlight the noteworthy papers and provide an overview of the sessions.

Requirements and Applications

A plenary session of the conference reviewed metal matrix composites and powder processing for aerospace structural and engine applications, automotive applications, and the nondestructive testing of metal matrix composites. Drs. F.H. Froes and J. Wadsworth presented the lead paper addressing aerospace structural applications; it highlighted alloys and systems based on aluminum, titanium, magnesium, niobium, and beryllium matrices. In the assessment of powder processed alloys, the benefits derived from the fine microstructure must be balanced by improved process and cleanliness control in order to achieve design confidence and eventual applications. The property improvements demonstrated with fiber and whisker reinforcements are sufficient for several aerospace structural applications; however, they may be economically prohibitive for commercial systems.

For application of powder processed and composite materials for aerospace engine applications, Dr. D. Driver of Rolls Royce compared the design and materials requirements of civilian versus military engines. (See Figures 1 and 2.) Accepting the potential weight saving from composite substitutions, additional design changes can further reduce weight; e.g., integrally bladed discs; i.e., "blisks", hollow blading, composite rings, and spacers. Dr. Driver stressed that the rate of materials development and eventual application is governed by the rate of manufacturing process development. Without sufficient process control and reliability, the potential of metal matrix composites and powder processed alloys

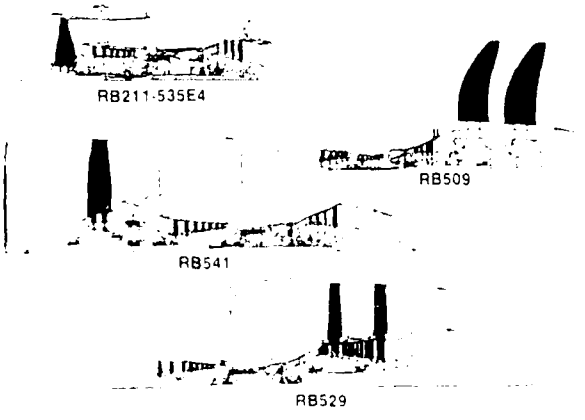

Figure 1. Trends in Civil Engine Configurations: Comparison of RB211, RB509, RB529, and RB541

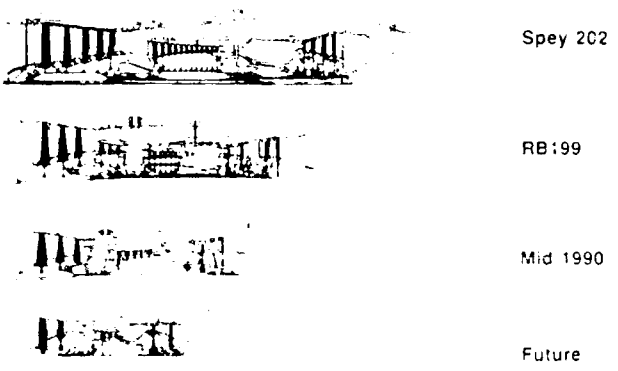

Figure 2. Trends in Military Engine Configurations

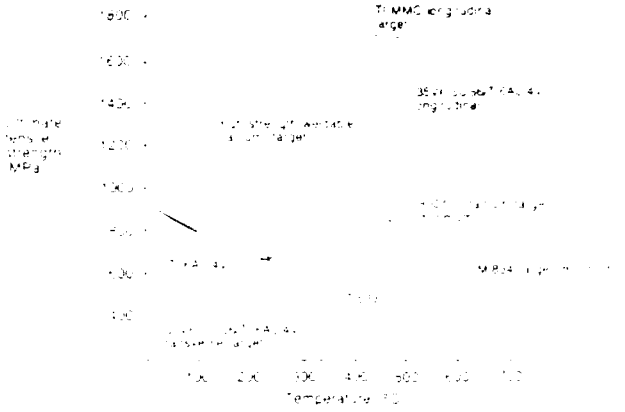

Figure 4. Ultimate Tensile Strength of Titanium Alloys and Metal Matrix Composites

may not be realized. Potential engine application for titanium matrix composites and the strength temperature response is shown in Figures 3 and 4, respectively. In addition, emphasis should be shifted to inspection and control of the process as well as the product. As a commentary, designers have been utilizing "isotropic" metallic systems in the past; however, in fact they are often anisotropic. Therefore, designers must accept, learn to deal with, and specify genuine anisotropic or quasi-isotropic fiber reinforced composite and metallic systems and address the three-dimensional physical and structural nature of these "anisotropic" and composite systems.

J.S. O'Neill provided an energy- and environmentally-related review of New Materials for Automotive Appli-

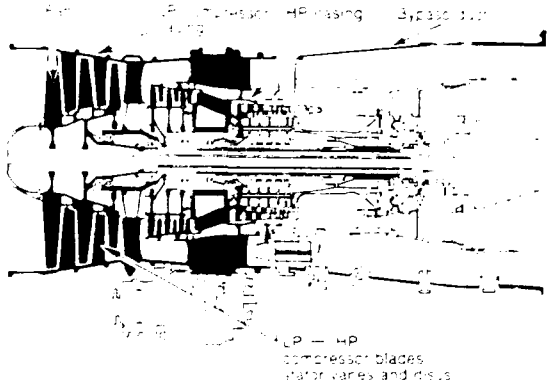

Figure 3. Potential Applications for Titanium Metal Matrix Composites in Military Engines

cations. Considerations for improved fuel efficiency are design- and materials-related. From a design viewpoint, improved aerodynamics, engine efficiency, and power transmissions coupled with reduced weight will reduce fuel consumption. Weight reduction is materials-related with the choices based on light alloys, polymeric materials, and/or composite structures. The materials choices and property advantages presented are dampened by the economic pressures of the automotive industry particularly in the non-niche, mass production market

Process Technology

Papers on process technology included rapid solidification, mechanical alloying, spray deposition, injection molding of metal powders, melt spinning and stir casting of composites. Two notable contributions were by Drs. D.W. Kahl and J. Leupp, Swiss Aluminum Ltd. "High Performance Aluminum Produced by Spray Deposition" and "Production, Properties and Applications of Particulate Reinforced Aluminum Alloy Composites" were presented by Dr. C. Baker, Alcan International. Both sought to enhance the strength of aluminum alloys via particulate reinforcements, thereby providing for a cost effective reinforcement system. The development of the spray deposition process has blossomed since the developments by Professor Singer at Swansea University, U.K. Currently for aluminum alloys, pilot plants have been initiated at Osprey, Alcan, Pechinney, Alusuisse, and a plant manufacturing license to Mannesmann Demag. Via a cospray deposition, variations of alloy chemistry and reinforcement can be varied. The strength response of the Alusuisse Al-Zn-Mg; i.e., a heat-treated 7000 series alloy without reinforcement, had a yield strength of 730 MPa coupled with an elongation of 8 percent. In addition, a spray deposited experimental alloy--Al-Cu-X--is depicted in Figure 5 in terms of elevated temperature strength versus temperature. Dr. C. Baker of Alcan presented an excellent summary of SiC reinforced foundry alloys; e.g., A356, A357, and A332; wrought alloys with Al_2O_3 particulate reinforcements and cosprayed and extruded 2618 and 8090 alloys with 12-13 percent SiC particulate reinforcements. The cospray process is currently under development at Alcan's Banbury Laboratory with billet sizes being scaled up to 250 kg.

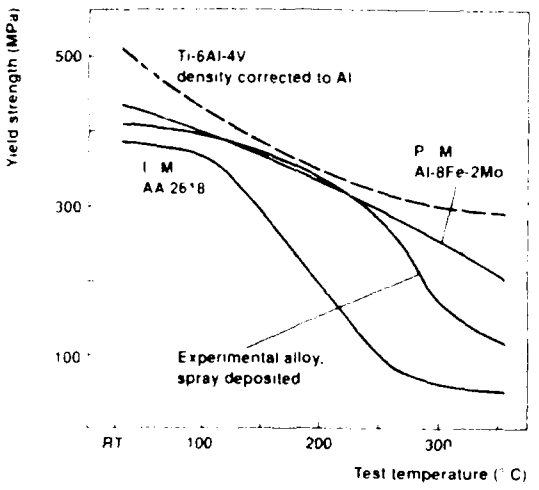

Figure 5. Yield Strength Versus Temperature for Al and Ti-Alloys Produced by Different Techniques

In a further development on metal matrix composites for automotive applications, a paper by E.J. Peters of BP America reviewed a cost-effective approach to squeeze cast composites utilizing alumina-silica fibres; i.e., Saffil and Fiberfax. Although the strengths are not competitive with previously considered systems, the wear response and physical properties may be sufficient for automotive castings and other wear resistant applications.

The properties and fabrication of carbon/carbon composites was considered by Drs. T. Cho and A. Okura, Institute of Industrial Science, University of Tokyo, Japan. In their approach, preformed yarns were combined with a petroleum pitch binder and a low-temperature debinder processing; e.g., 24 hrs at 600°C. The thermal treatment coupled with a secondary heat treatment temperature ranging from 600°C to 2000°C with times less than 48 hours. The variation of strength, density, and modulus is depicted in Figure 6. Unidirectional carbon/carbon composites had strengths ranging from 500 to 700 MPa while the cloth carbon/carbon systems were in the range of 200-300 MPa with lower strengths and higher moduli achieved at higher processing temperatures.

Powders and Magnetics

A smaller number of magnetics papers were concerned with processing aspects; i.e., melt spinning of alloys for high energy, rare earth magnets, the development of high saturation Co-Fe alloys; i.e., 49Co/49Fe/2X where X = V, Nb or Ta. In addition, papers included the production of superfine manganese powders, design of permanent magnetic generators, time and rate dependence of the coercivity of recording media.

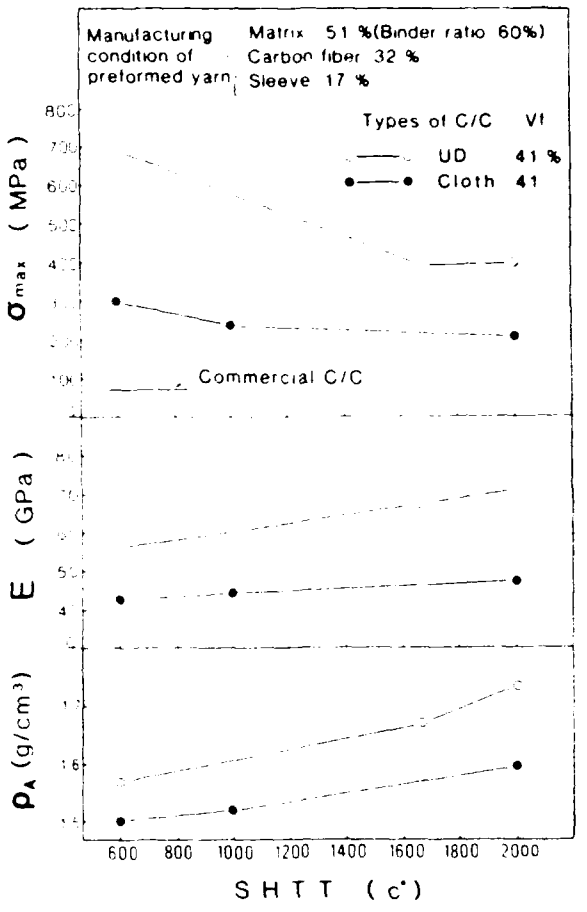

Figure 6. Change of Bending Strength (σ_{max}), Young's Modulus (E), and Apparent Density (ρ_A) of C/C Directional and Cloth Sheets Treatment Up to 2000°C

Summary

The application of metal matrix composites can be viewed in two areas; i.e., low-cost, mass production applications; and a high-performance/high-cost regime. In the first area, several companies are testing the materials waters; e.g., BP, Alcan, for aluminum matrix systems. For the high-performance sector, a possible future trend for materials utilization for engine application was shown by Dr. Driver of Rolls Royce. (See Figure 7.) A rapid decrease in the utilization of nickel and titanium is depicted coupled with the virtual elimination of aluminum. A steady growth of carbon/carbon systems is forecast with a dramatic increase in metal and ceramic matrix composites over the 2000-2010 timeframe. The projected trends appear optimistic, particularly for metal and ceramic matrix composites in the materials competitive commercial sector. The future decrease in titanium utilization is doubted. Nethertheless, if the projections hold, it would require a coupling of materials processing and composite design of thick, complex sections and the manufacturing ability of accurate, intricate structural shapes. It is not

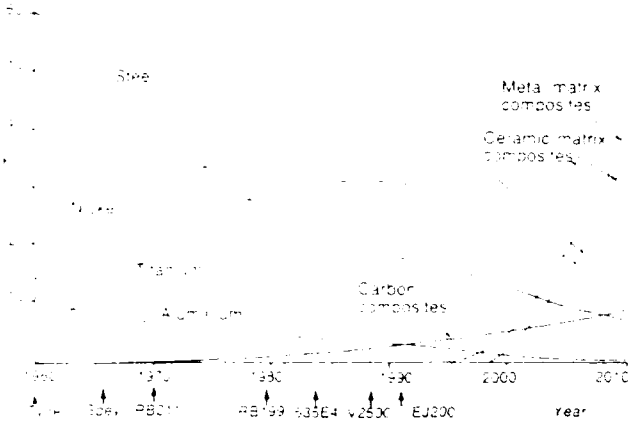

Figure 7. Materials Trends in Jet Engine Material Usage

clear if a design database, manufacturing, joining and inspection capabilities can be effectively established within this timeframe.

The conference proceedings can be obtained from:

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- Figures 1, 2, 3, 4, and 7 - Dr. D. Driver, Rolls Royce plc, U.K.
- Figure 5 - Dr. W. Kahl and Dr. J. Leupp, Swiss Aluminum Ltd., Switzerland
- Figure 6 - Dr. T. Cho and Dr. A. Okura, Institute of Industrial Science, University of Tokyo

MATHEMATICS

Computer Graphics International '89

by Richard Franke, formerly the Liaison Scientist for Mathematics and Scientific Computing in Europe and the Middle East for the Office of Naval Research European Office. In September 1989 Dr. Franke returned to the Naval Postgraduate School, Monterey, California, where he is a Professor of Mathematics.

Introduction

The Computer Graphics Society held its seventh annual meeting on June 27-30, 1989, at the University of Leeds, U.K. The meeting was preceded by 3 1/2 days of tutorials covering several computer graphics topics. The organizing and program committees were international, as far flung as Europe, the U.S., Canada, Japan, and New Zealand, and the participants even more so. The invited speakers and the papers selected to be presented treated many topics, including algorithms, computational geometry, computer animation, graphics interface and theory, hardware, image processing, modeling and computer-aided design, ray tracing, rendering, and applications. Six one-hour invited talks and 40 twenty-minute contributed papers were given. The proceedings was distributed at the conference, and contains most of the papers (Earnshaw and Wyvill). In addition to the formal presentations, there were book company and state-of-the-art graphics equipment displays by Silicon Graphics, Hewlett-Packard, Meiko Scientific, Sun Microsystems, Stellar Computer, and DuPont Pixel Systems. Because the proceedings are already available, I will comment primarily about the invited presentations.

Interactive Displays for the 21st Century: Beyond the Desktop Metaphor (keynote address)

Professor Henry Fuchs, University of North Carolina

Fuchs' concern was that, while we have very useful graphics tools, they are essentially like a desktop (in particular, two-dimensional [2-D]), and it is generally not possible to interact with the graphics in a three-dimensional (3-D) way. He recalled Ivan Sutherland's head-mounted display introduced over 20 years ago, indicating that (in a sophisticated enough form, not yet available) it would be very useful. One instance he cited was that one would be able to "take a walk through a virtual building" proposed by an architect. A short video showed how this might work, with the walker walking on a treadmill, viewing the computer-generated picture on a screen in headgear. The computer would generate the view based on

the head and body movements of the walker. There are several problems that still need to be solved: real-time image generation (apparently even a slight lag tends to make the walker ill), tracking head and hand movements, and a suitable display. While great strides have been made on displays since Sutherland first made his proposal, Fuchs would like to see something about the size of clip-on sunglasses. He thinks many researchers have stopped thinking about such matters because the hardware is not available. However, not everyone has since video games are now becoming available that use a special glove to sense hand movements, the movements then controlling the action on the screen. In addition, it was pointed out by David Rogers, U.S. Naval Academy, that heads-up displays for military purposes also have similar problems. Fuchs would like to see the desktop type of interface used by the Macintosh and other computers evolve to an office type of interface; i.e., 3-D.

The Mechanical Universe and Visual Icons for Physics

Dr. James F. Blinn, California Institute of Technology

Blinn spoke about his experiences and some of the results in designing computer graphics segments for the university level introductory physics course for television--*The Mechanical Universe*. The programing consists of 56 hours of time, each one-hour segment containing about 10 minutes of computer graphics-generated pictures. I will mention several things that were considered and how it was decided to present the information. Position, velocity, and acceleration are related through differentiation/integration; symbols and vectors for these quantities were color-coded--green for position, yellow for velocity, and red for acceleration, moving toward the red part of the spectrum when differentiation is performed. This idea was carried over to other quantities related in this way, with the angular momentum being light blue, and torque being lavender. A "differentiation machine" was employed, with functions being fed in one side, and the derivative coming out the other. Of course, to integrate, the lever was moved in the opposite direction, and the process was reversed. Algebraic manipulations were animated; e.g., with a symbol moving from the denominator of one side of the equation to the numerator of the other side. Equations that were to be remembered by the viewer (e.g., $r = \sin \Theta$) were moved to a symbolic head, the top popping up like a flip-top dustbin to receive the equation. Retrieval was the reverse. Other tricks used included suspending shadowed equations above the relevant picture; e.g., for the area under a curve the area is shown in a plane, with the equation floating above and to the side of it. This served to set off the equation from the picture while giving a nice 3-D effect. I will be looking forward to seeing this series upon my return to the U.S. The next project is actually a precursor to the physics, being a course for the prerequisite mathematics at the high school level.

A Cellular Self-Reproducing Automata as a Parallel Processing Model for Botanical Colony Growth Pattern Simulation

Tosiyasu L. Kunii and Yoshiaki Takai, University of Tokyo

The speakers discussed self-reproducing automata as a simulation of life and as a model for parallel computation. The pioneer work was done by Von Neumann, but simpler examples are by Langton. (Note: the well known game of "Life" by Conway [see Gardner] does not satisfy the requirements of self-reproducibility.) Some graphical examples of cellular automata that simulate trees were presented. Here there are potential applications in landscape design. More complicated examples showing growth in a ring shape, with the inner core dying out when there was no room to reproduce (somewhat similar to the phenomenon observed in cities), were shown. All examples were 2-D. In further work, they want to consider the effects of mutations and environmental factors such as temperature, sunlight, and nourishment.

Computational Geometry: Review and Current Developments

Godfried T. Toussaint, McGill University

Toussaint first indicated several ways that computational geometry has changed in the past few years: (1) early problems dealt with line segments, now curves are widely considered; (2) 3-dimensions are now much more widely considered; (3) new measures of distance are considered, such as rectilinear, Minkowski, and geodesic, instead of only Euclidean; (4) parallel algorithms instead of serial are investigated; (5) numerical aspects are considered now; (6) expected complexity receives much more attention, whereas traditionally only worst-case complexity was considered; (7) instead of the strictly geometrical viewpoint, graph theory is incorporated into the problems; and (8) iterative techniques receive wide attention in addition to the traditional combinatorial techniques. The search for linear time algorithms still is important, and techniques such as "throw away" principles and "bucket methods" have helped in the derivation of such algorithms. However, as one moves into high dimensions, the problems become much more complicated. For example, a polyhedron in 2-D can always be triangulated without introducing additional vertices; the best time to date is $O(n \log \log n)$, with the search for an $O(n)$ algorithm being one of the outstanding problems in computational geometry. In 3-D, however, not all polyhedra can be triangulated (for convenience and as seems to

be current practice, I say "triangulated" even though the pieces are tetrahedra), and further it has recently been shown that the problem of deciding whether a 3-D polyhedron can be triangulated is NP-complete (Rupert and Seidel). Other problems discussed by Toussaint included visibility problems, including visibility from a point, visibility from the end of articulated arms, and the "Italian TV antennae" problem (at which point can the shortest tower be built so that all points on a polygonal surface can be seen from the top of the tower?).

Tools for the Formal Development of Rasterisation Algorithms

John V. Tucker, University of Leeds

This talk concerned the mathematical foundations of step-wise refinement of rasterization algorithms. Rasterization algorithms map continuous lines and more generally, curves to a discrete space (a raster display device) on which the "curve" is displayed. The concepts involved are rather technical, using the ideas of abstract data types such as "many sorted algebras." (See the full conference paper by Eker and Tucker.)

Visualization in Scientific Computing: Achievements and Prospects

Michael J. Wozny, Rensselaer Polytechnic Institute

Wozny uses the term *scientific visualization* to describe the process of extracting meaningful information, in an interactive manner, from a graphics representation of a physical phenomenon. The term evolved from the National Science Foundation Supercomputer centers and their users to describe what they felt was needed to cope with the large amount of data being generated by the machines. According to a survey by the National Research Council concerning problems with supercomputers, visualization ranked high, especially among veteran users (things such as cost and difficulty of using ranked first among beginning users). Although graphics workstations with impressive capabilities are now available, and graphical interpretation of results seems to be needed across a broad spectrum of fields, it is not yet clear whether it is possible to develop a *spreadsheet* of visualization. (Several efforts are underway in this direction, including Advanced Visualization System, a preliminary version was demonstrated at the conference by Stellar Computer.) Wozny believes that, for the moment, the most successful visualization techniques will consist in the application of known methods in graphics by persons knowledgeable in the application field. New ideas are necessary, though, for visualization of data in three, four, and more dimensions. As an example of how visualization may also push mathematics, he cited the recent discovery of several new minimal surfaces that were first generated and displayed by computer graphics, then verified mathematically. One strong point made by Wozny is that scientific visualization is more than computer graphics and requires a total modeling environment, since graphical representation of data based on inadequate models is meaningless.

Wozny also noted that special purpose computers; e.g., a Maxwell's equation machine, have been talked about for a long time, with little in that direction actually having been built. Graphics workstations have special graphics engines built into them, and Wozny thinks that visualization may eventually require specialized computers to simulate the phenomenon being investigated (he seemed to think it was premature to speculate).

A Light and Easy Historical Personal Perspective on Computer Graphics

David F. Rogers, U.S. Naval Academy

This talk was given after the conference banquet, and was illustrated by slides and movies taken over a period of more than 20 years. Rogers gave a review of his and the Naval Academy's experiences in computer graphics, starting in the 1960s through the present. He began with a teletype and midshipmen transcribing data from experiments, moved on to what may have been the first classroom equipped with workstations (Tektronix 4051s, before the term workstations was coined), to interactive real-time ship line design with subsequent numerically controlled milling of the hull from wood followed by towing tank tests, to the present. Rogers gave an entertaining account of the problems and excitement of being involved at the forefront of this exciting field.

Final Comments

This was an interesting meeting in most respects, but given the adequate publicity and the potential size of the audience, it was surprisingly small with fewer than 140 attendees. Perhaps this reflects that there are other graphics-oriented meetings, such as Eurographics and Siggraph, that command the attention of many with similar interests. The next annual meeting will be held in Singapore, June 26-30, 1990.

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Central Institute for Industrial Research, Oslo

by Richard Franke

Introduction

The Senter for Industriforskning (SI) in Oslo, Norway, is a multidisciplinary center for technological research oriented toward industrial applications, and employs about 350 persons, about 250 of whom are in technical disciplines. The SI is administered by a board consisting of members from the Federation of Norwegian Industries, the Royal Norwegian Council for Scientific and Industrial Research (NTNF), the University of Oslo, and SI. Over the past several years, SI has become essentially self-supporting, with only about 5 percent of their funds provided by NTNF, the remainder provided by industrial and government contracts.

Divisional breakdown:

- Automation - offshore instrumentation, production automation, microelectronics, industrial measurement techniques, and electronic information exchange; the division employs about 55 persons.
- Information Technology - geometric modeling, knowledge-based systems, distributed information systems, and computer-integrated manufacturing; the division employs about 50 persons.
- Industrial Chemistry - biotechnology, oil and gas activities, and analytical and environmental chemistry; the division employs about 90 persons.
- Materials Technology - polymers, light metals and steel, and ceramics and laser treatment; the division employs about 50 persons.
- Other - a group for biomedical technology concerned with services for the handicapped, instrumentation and an instrumentation workshop, and short courses.

Geometric Modeling Group

I visited with Tor Dokken, head of the Geometric Modeling group in the Information Technology Division, which employs about 10 persons. The activities of the group are directed primarily at building software packages for various modeling purposes. These packages are often generated specifically for a client's specialized problem, but in other cases may be for sale by SI. Some of their work is based on research results (some joint work) with Professor Tom Lyche and his students at the University of Oslo (see following article). I will describe some of the projects in the group at SI.

The ship design system--AUTOKON--was one of the first projects by the group, which began in the late 1950s. An old (but less ancient) project at SI was the implementation of a suite of spline function routines in Fortran. The SI Spline Library package was the result and is widely used at SI, the University of Oslo, and at industrial sites that bought the package. More recent work is on the development of box-spline applications for problems where they are suitable.

The results of a large joint German/Norwegian project--the advanced production system-sculptured surface (APS-SS) for computer-aided design and manufacturing (CAD/CAM)--is now available. The package is modular and can be integrated into existing CAD/CAM packages. This is being done in at least two cases--Norsk Data GmbH is integrating the package into its TECHNOVISION system, and ISYKON GmbH is integrating it into PROREN. Some special purpose systems have been made by using the APS-SS modules as the core of the system. One such system is used by Kværner Brug A/S for designing water turbine blades. The APS-SS system is based on B-splines, but conversion from other representations to B-splines is available.

The latter idea is the basis for another project--transferring the geometry between CAD/CAM systems that use different representations. One such system transfers data from the VDAFS format (used by the Association of German Automotive Manufacturers and their suppliers)

to MOLDFLOW format. The MOLDFLOW (by the Moldflow Company) is a system that simulates injection molding of plastic parts. In addition to simulating the injection process, another computer code called Moldtemp simulates the cooling process after injection. Since this program uses the MOLDFLOW geometry format, conversion of the data format might be used for this purpose alone.

The TERMOS is a digital terrain modeling system and was developed as a joint venture between SI and The Norwegian Geotechnical Institute. The model can be created from digitized maps, gridded points, or randomly spaced points. Cubic splines are used on a grid of up to 900x900 with an area of up to 700 km^2, with a 20-m contour interval. The system can be integrated with other systems; e.g., houses from a CAD system for designing houses can be placed on the modeled terrain and manipulated to gain an idea of the visual aspects of a housing development. In a somewhat related effort in cooperation with the Vision Group at SI, work is proceeding on a system for automatic reconstruction of objects from measurements. Such an object need not be representable as a function such as is done in TERMOS. The system will automatically detect edges.

Other projects in the Geometric Modeling group are:

- Automatic scanning of engineering drawings - the representation of curves is in spline format, which is easily converted to alternate formats
- Computer integrated robotization - the project is to provide an efficient tool for planning, programming, simulating, initiating, and surveying small-scale robotized production
- Other - interests that might attract funds are in preprocessing for finite element analysis, animation, optimization. data reduction, quality control, image processing, and cartography.

Final Comments

The SI, (particularly, the Geometric Modeling group) has moved to an essentially self-supporting organization by providing market-oriented technological research and development of the related products.

University of Oslo

by Richard Franke

Introduction

I visited in two departments at the Universitetet in Oslo--the Institutt for Informatikk and the Institutt for Geofysikk. The University of Oslo is located north of central Oslo, on the hills at Blindern. The university is presently being expanded, and the new building housing the Computer Science Department (CSD) (and another new building) is temporarily a little isolated from the older part of the university (west of the tram tracks with no convenient overpass). The new location of the CSD is adjacent to an industrial park, in particular it is close to the Senter for Industriforskning (SI), with whom some of the people I talked to have close ties (see preceding article).

Computer Science Department

Professor Tom Lyche was my contact in the CSD which has about 20 faculty members. There are 60-70 Master of Science graduates per year with about 5 Ph.D.s granted with hopes of increasing the Ph.D. output to about 10 per year. The CSD is the professional home of Ole-Johan Dahl and Kristen Nygaard, the inventors of the first object oriented language, Simula.

I spoke with Professor Knut Liestl, assistant department chairman. According to Liestl, the CSD has five interest areas:

- Computer Science - languages, compilers, and program verification
- Cybernetics - neural networks, image and signal processing
- Very Large Scale Integration (VLSI) design - low voltage transistors, analog VLSI
- Numerical analysis - linear algebra, numerical solution of pde's, spline functions
- Systems group - social impacts of computing.

The Computer Science area has the biggest faculty, with about three or four persons each in the others.

I spoke with A. Tveito about his work in two numerical analysis areas. He has investigated the use of preconditioners with the conjugate gradient method for solving linear systems, showing that preconditioners based on a certain class of incomplete LU factorizations are stable, as are their factorizations. (See Bruaset, et al.) They have also performed a numerical investigation of the use of conjugate gradient-like methods to solve linear systems

arising from the finite element formulation for the solution of a non-selfadjoint pde in two dimensions, using linear elements. The amount of work required to reduce the residuals by a factor of 10^{-4} was computed for more than 75 iterative methods, including some of which used a modified incomplete LU factorization for a preconditioner. The results are given in Langtangen and Tveito. The results generally indicate that preconditioning leads to a big saving in computations, and that the restarting methods given by Saad and Schultz work very well, as does the CGS method of Sonneveld.

Tveito also works on problems related to oil recovery by water or water-polymer injections. The problem is modeled by a system of hyperbolic conservation laws. In the scalar case, the theoretical aspects concerning existence and uniqueness of solutions is well understood. In the case of systems of equations, the situation is not so satisfactory, with no global analysis of existence and uniqueness being available. Of course, this complicates the problem of numerical solution of such systems. The work of the group in Oslo is mainly toward the theoretical aspects of systems of hyperbolic conservation laws with the ultimate view being the implications for numerical solutions. Some recent work is in Johansen and Winther, and Tveito and Winther. In the latter report, it is shown that a subsequence of the family of approximate solutions obtained by finite difference approximation converges to a weak solution, which in turn satisfies a set of entropy conditions.

Professor Ragnar Winther has previously worked on problems related to water waves, and has recently published joint work with Jerry L. Bona concerning the Korteweg-DeVries equation (Bona and Winther, 1989). This work concerns the dependence of the solution to the equation on the initial and boundary conditions for the case of small amplitude, long wave propagation for the quarter plane. The principal result is that the solution depends continuously on the initial and the boundary data.

Lyche is well known in spline approximation theory, recently working in matters related to knot insertion and removal for splines. He is one of the inventors of the "Oslo algorithm" for knot insertion (Lyche, 1988). Lyche was one of the co-organizers of the conference on Mathematical Methods in computer-aided geometric design (CADG) held last year in Oslo with Office of Naval Research European Office support (Lyche and Schumaker for proceedings).

Another topic is using box splines for applications such as interpolation (Dæhlen and Lyche, 1988). Box splines are piecewise polynomials defined over certain kinds of regular multidirectional meshes in multidimensional spaces. Sets of multivariate functions cannot be unisolvent (unisolvent essentially means the set can always be used as a basis set for interpolation), but the authors show that under certain restrictions on the data points, the interpolation problem is solvable with C^0 quadratic box splines.

Very recent work by Arge and Dæhlen (1989) concerns interpolation at a subset of grid points in a region over which box splines have been defined. In general, the dimension of the space of box splines is larger than the number of data points. The authors consider the $s+1$ directional mesh in s-dimensional space. They show that solutions to the interpolation problem exist, and then use the extra degrees of freedom to find the interpolating box spline that minimizes the integral of the sum of the squares of the second derivatives in the $s+1$ directions. Several examples are given. In interpolation problems on grids, or subsets of grids, tensor product splines can be used. However, the authors feel that the extra knot lines of box splines may give useful additional flexibility.

Continuing work by Dæhlen and coworkers is on curve fitting with constraints, such as monotonicity and extraction of features from parametric spline curves. In the latter instance, the applications are to character recognition in handwritten numerals (Dæhlen, et al.). Dæhlen is employed at SI, as are some other students of Lyche.

Lyche and his students have been working on the problem of knot removal for curves and surfaces defined in terms of their B-spline representation. Such a process has many potential applications, such as adaptive function approximation and data fitting in the univariate and multivariate cases, degree reduction, basis conversion, and data compression. In Lyche and Mrken (1988), the strategy is defined, based on the idea of determining a weight for each data point (a measure of the importance of the point), removal of a subset of the points with small weights, and calculation of the resulting approximation with fewer knots. The process can be repeated if a given tolerance between the original data and the approximating function is satisfied. The process leads to a smaller set of knots (sometimes much smaller) while still giving a good approximation. In general, the algorithm does not result in the approximation with the smallest number of knots, but one with a reasonably small number. By beginning with many knots of suitable multiplicity, an initial piecewise linear approximation results, with the algorithm retaining multiple knots at points where the function has derivative discontinuities. In the case of function approximation, the beginning data could be from sampling the function on a rather dense set. The work has also been extended to the parametric case (Lyche and Mrken, 1987). More recent work (Arge, et al.) considers the knot removal process coupled with constrained approximations. Constraints could be a variety of things, such as one-sided approximation, convexity, interpolation, or monotonicity. For the bivariate case using tensor products, the algorithm leads to removal of knot lines.

The case of scattered data is under consideration; although in the present work, a surface is constructed from

the scattered data using a triangle method, and this surface is then approximated by a tensor product B-spline surface, starting with a sufficiently large number of knot lines. A truly scattered data approach would be desirable, but is also difficult. Some work in this direction has been carried out by Bozzini, et al., and by LeMéhauté and Lafranche. The problem of determining which of a large set of scattered data points is necessary for the definition of a surface is an important one because with modern data collection methods a surfeit of data often results.

Geophysics Institute

I visited with Professor Arne Bratseth at the Geophysics Institute. Bratseth has worked with the Norwegian Meteorological Center on problems related to objective analysis and initialization; he also is the originator of the schemes presently in use at the center.

The objective analysis scheme is interesting because it is a successive corrections type of scheme, but one that uses the spatial covariance function as the weighing function, and if iterated to convergence gives the corresponding statistical interpolation result (Bratseth, 1986). The rate of convergence is related to the correlation distance (meaning the distance at which the spatial correlation function decays to a certain value), with shorter correlation distance implying faster convergence. Since the spatial correlation function is inferred from historical data for statistical schemes, that cannot be used as a parameter. The first few iterations retrieve the slow modes, while continuing the iteration brings in the fast modes, but typically at a slow convergence rate. Since the slow modes are the most important, convergence for the fast modes does not seem to be a serious problem, and this would be especially true in data sparse regions. In any case, Bratseth does not look at the scheme as a way to approximate the statistical interpolation, but rather as an alternative successive correction. Some investigation of the scheme in a simulation is given in Franke, where it performs reasonably well. The actual performance of an objective analysis is much more complicated than obtaining small analysis errors, so the filtering aspects of the iterative scheme may be more important in the end than smallest possible analysis errors.

The initialization used by the Norwegian Meteorological Center for their limited area prediction model is based on the idea of suppression of modes moving faster than about 70 m/s while retaining those moving slower than about 30 m/s. This is achieved by three iterations that can be viewed as six time integration steps, with parameters chosen in a suitable manner. Some characteristics of the normal modes are used to choose parameter values, but the normal modes themselves need not (and have not) been computed for the polar stereographic coordinates used by the model. One of the principal advantages is that the scheme is effective while being simple to implement, which is important for facilities with limited resources to spend on the problem. A full description and results of testing are given in Bratseth (1988).

Conclusion

The CSD at the University of Oslo is active in numerical analysis, especially for partial differential equations, and splines for CAGD purposes as well as for representation of curves and surfaces. The theoretical work on systems of hyperbolic conservation laws has important consequences for the numerical solution of such systems. The work on splines is at the leading edge in representation of curves and surfaces when vast amounts of data are available.

Bratseth's work at the Geophysics Institute is directly used by the Norwegian Meteorological Center in their limited area numerical weather prediction model. This work has resulted in good analysis and initialization schemes, especially suitable for a facility with limited manpower and computational resources.

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IBM European Center for Scientific and Engineering Computing, Italy

by Richard Franke

Introduction

The IBM European Center for Scientific and Engineering Computing (ECSEC) is located in Rome, Italy. Established in 1984, it was the first of four IBM research centers that focus on numerically intensive computing. The others are in Kingston, New York (1986); Palo Alto, California (1986); and Tokyo, Japan (1987). The other IBM research centers are generally specialized toward more specific research areas or problems (an atypical example is the Bergen Scientific Center [see *ESNIB* 89-07:47-52] but there are several in Europe).

My host was Dr. Piero Sguazzero, the Senior Technical Staff Member; according to him, the center now employs about 20 scientists (about 25 positions are available). Because of the nature of the ECSEC, each scientific employee must be capable of following a problem through from its physical description, to application of appropriate numerical techniques, and eventual implementation on the IBM 3090/600E at ECSEC. There is also an active scientific visitor program for researchers who want to perform joint investigations with members of the staff at ECSEC. The IBM 3090/600E (6 processors, each with vector facility) at ECSEC has 256 MB of central memory and 1 GB of extended memory. Graphics is performed on IBM 5080 workstations.

The areas of research at the ECSEC are very strongly driven by the customers for the IBM 3090 with multiple vector facilities. A typical problem is approached from the point of view of the customer who wants to use his machine efficiently. In addition to defining efficient algorithms and techniques for multiprocessing with the vector facilities, the investigation may result in suggestions for new architectural features. I will discuss the five areas of investigation at ECSEC.

Software Tools for Numerically Intensive Computing

For users to be able to use multitasking vector processors efficiently, software must aid in the structuring of the problem so that vectorizing of inner loops can be efficiently carried out, while also treating the parallelization of outer loops. The IBM has such a product--Parallel Fortran--a superset of the VS Fortran compiler. Studies of using this compiler for some engineering problems have shown that when the granularity (amount of computation within the parallel tasks) is large enough, speedups greater than 5 are possible on a six-processor machine (see Gentzsch, et al.).

Even though a large amount of central storage is now available on many machines, virtual storage must still be used, which is then mapped into real storage by a process

called paging. Performance of large applications programs that access data in predictable order can be improved if the program is allowed to control paging. This is called "direct control of paging," and application of the idea to an example in elastic modeling is given in Carnevali, et al.

The frequent necessity to solve large sparse systems of linear equations is addressed by ECSEC in implementing methods included in the IBM Engineering and Scientific Subroutine Library (ESSL). These are based on conjugate gradient techniques and extensions to that method. The conjugate gradient routines for solution of sparse systems of equations in Release 2 of the ESSL are described in Radicati and Vitaletti. Preconditioning is by an incomplete Cholesky factorization, or by the diagonal. The compressed storage scheme used gives the nonzero elements of each row, with a pointer to the column numbers. If a row has fewer than largest number of nonzero elements in any row, entries are padded with zeros. On a test problem with 109,375 unknowns arising from the numerical solution of a three-dimensional (3-D) diffusion problem over unit cube with a corner missing, speedup of 4 over the scalar version of ITPACK (see Kincaid, et al.) and about 1.5 over the vector version of ITPACK routines were reported for diagonal preconditioning.

In the case of greatly varying numbers of elements per row, the compressed storage scheme is inefficient. Paolini and Radicati have proposed a data structure for such problems which efficiently vectorize conjugate gradient algorithms. The basic idea is to sort the rows into decreasing numbers of nonzero elements. Then, by making the vector operations shorter as one proceeds across the columns of the pointer matrix, operations with zero elements are avoided. Their computational results show that the sparsity pattern of the matrices has little effect in the speedup achieved over the scalar code. It would have been interesting to see a comparison with the vectorized version of the compressed storage scheme.

While the usual effort is toward efficient use of the IBM 3090, ECSEC is conducting a joint project with the Numerical Algorithms Group to evaluate the use of the level 3 (meaning they involve matrix-matrix operations) Basic Linear Algebra Subroutines (BLAS). The BLAS are designed to be portable across machines for scientific computation while still retaining a significant degree of efficiency. Related work is reported in Mayes and Radicati, where they conclude that the use of Level 3 BLAS is more efficient than level 2 (matrix-vector operations) BLAS for banded matrices when the bandwidth is large, running at about twice the speed. Even when the bandwidth is small, the performance is not too much worse. Use of tuned modifications to take advantage of sparsity should improve the performance for small bandwidths.

Structural Engineering

This area of investigation is mainly focused on the migration of various large structural analysis codes to the IBM 3090 multiprocessor. Some of these codes are also useful for other field problems, such as fluid flow and heat transfer. A particular emphasis was concentrated on the ADINA code--a large finite element program. An intensive study of the code for linear analysis showed that the major computation is done in the solution of linear systems, taking from 50-95 percent of the time. Further studies indicated that iterative solvers were efficient for structural problems (although less so for fluid flow problems) (see Angeleri, et al.).

The revised version of the ADINA code has been used in a feasibility study of the Messina Straits bridge. The study was carried out jointly with Stetto di Messina S.p.a., the company appointed by the Italian government to study the feasibility, and to design and build the bridge. The proposal is for a suspension bridge with two 400-m towers on the Calabrian and Sicilian shores and an overall length of 3.4 km, which would be the longest in the world. The successful study involved both static and dynamic analyses, and ECSEC will probably participate in the final design phase to be started soon.

Fluid Dynamics

Investigation of turbulent flows is one of the main research topics at ECSEC. Two-dimensional (2-D) flows have been investigated to high accuracy using spectral methods and a 1024x1024 grid with periodic boundary conditions and a variety of initial and forcing functions. Small scale coherent vortices can only be observed under high-resolution schemes and are as stable as the large-scale vortices (see Benzi, et al. and Legras, et al.). Two-dimensional color displays of some turbulence calculations were prominently displayed in offices and halls. The challenge now is three dimensional (3-D) turbulence. I saw a series of 3-D views of the evolution of two interacting vortex cylinders. Like many organizations, they are beginning to think of ways to visualize 3-D turbulence.

For nonrectangular geometries, the Mask Method has been developed for 2-D incompressible viscous flows in an arbitrary geometry. A pseudospectal formulation is used, with the geometry being introduced by directly forcing the velocity field near the boundaries. The procedure is amenable to vectorization (see Briscolini and Santangelo). The method has been applied to the problem of turbulent flow between rotating disks, a problem of great interest for storage device makers. The method has been used to study the transition to turbulent flow as well as to simulate the statistical properties of the fully developed turbulent regime.

Alternative approaches based on Lattice Gas models are being investigated for the solution of Navier-Stokes equations. These models obey cellular automata rules, so they are discrete and involve logical operations. Thus, the simulation strategy can be solved exactly and the updating rules are very amenable to massive vector and parallel processing. The statistical nature of turbulence is one topic of investigation. The long-range forces governing the interaction between the coherent structures (vortices) in a 2-D fluid are correctly supported by the lattice gas dynamics. The ideas are also being extended to solve the Boltzmann equation. In this case, the computational cost seems to be competitive with spectral techniques, although for the Navier-Stokes equations they are more expensive (see Succi, et al., Succi and Benzi, and Higuera and Succi).

Turbulence also plays a role in the physics of thermonuclear plasmas. Because of strong interaction between the plasma and the electromagnetic field generated by the plasma, the system is more complex. The interaction can result in thermal losses at much higher rates that those predicted by classical transport theories based on the assumption of near equilibrium of the thermonuclear plasma. Because of the nonperturbative nature of the phenomenon, the results would probably be inaccessible without the use of numerically intensive computations.

Numerical Geophysics

Seismic processing and reservoir simulation are the topics under investigation here. Investigation of efficient algorithms for solution of elastic wave propagation problems using finite elements has shown that Newmark and explicit central differences are best for time integration. Also, the conjugate gradient method with compressed storage scheme is best for solution of the linear systems (see Seron, et al.). Evaluation of frequency domain methods for modeling and migration is being investigated. On parallel/vector architectures, optimal results are obtained by a multilevel parallelism: vectorization in the innermost loops and multiprocessing in the outer loops (see Kamel, et al.).

Exploratory Projects

These projects are grouped together only because of their common need of numerically intensive computing. The projects are in the areas of molecular modeling, neural networks, and econometric modeling.

The molecular modeling effort is in periodic crystals and arsenic clusters. A study is underway to compare the numerical results for the structure of thiorodoxin with the structure derived using x rays. In molecular dynamics, the static and dynamic properties of a liquid gold surface has been studied using a many-body force scheme (the so-called "glue" model) (see Iarlori, et al.).

The neural networks studies have focused on the potentials of Boolean architectures. Using a neural model based on neurons which are two-input gates, a "learning scheme" was used to attempt to train the architecture to perform some task. The training was regarded as an optimization process; the optimization is carried out using simulated annealing. Presently, a more general architecture is being considered, one able to deal with time varying inputs, with applications to pattern recognition as one possibility (see Patarnello and Carnevali).

In econometrics, the exploration is into how to understand and use more efficiently econometric models of interest in the economic and political fields. Stochastic simulation, analysis of the dynamic behavior of the model, parameter sensitivity analysis, and punctual linearization have been incorporated in an interactive way for large econometric models (see Angeloni, et al.).

Final Comments

The group at ECSEC is very active. A perusal of the list of activities for the past year includes nearly 50 published papers and more than 50 invited and contributed talks at meetings (mostly in Europe, but some in the U.S. and Japan). While the areas of investigation are driven by the customer base for the IBM 3090VF computer and thus have a ready audience, the results obtained are sometimes of a basic nature and generally interesting to scientists in the particular discipline as well as the computationally oriented public.

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Industrial Mathematics in Valenzano (Bari), Italy

by Richard Franke

TECNOPOLIS CSATA Novus Ortus (Tecnopolis) is a research and training facility located near Bari, Italy, at Valenzano. Tecnopolis grew out of a research and computer center, Centro Studi ed Applicazioni in Tecnologie Avanzate (CSATA), under the impetus of a program of the Ministry for Special Interventions in southern Italy aimed at increasing and revitalizing industry. Started in 1984 and built on land owned by the University of Bari, Tecnopolis is one of several facilities of its type that are planned for southern Italy. The complex contains office space and laboratory facilities for research branches of several industrial companies. The first phase of the development, about one-third of the anticipated final size, is now complete. The university connection began the cooperation between industry and academia which the center is designed to facilitate. Another of the goals of the project is for the incubation and birth of new companies, which may then remain at Tecnopolis or which may move out to other areas in southern Italy.

Located at Tecnopolis, CSATA operates the main computing center for the southern universities in Italy. The equipment available includes IBM 3081D and 4341, VAX 11/730, and other smaller machines. Also available are the Cray XMP/48 at the computer center in Bologna, an IBM 3090VF at the computer center operated by the Consiglio delle Nazionale Ricerche (CNR) at Pisa, and the Cray 2 at the Minnesota Supercomputer Center.

There are about 400 persons employed at Tecnopolis. The resident programs at the center are

- TECNOPOLIS CSATA Novus Ortus - research and development (R&D) in information technology, training, and technology transfer
- Laser Center - R&D of laser technology applications in industry and medicine
- Consortium NOVIMPRESA - a consortium of Fiat, IBM Italia, Istituto Mobiliare Italiano, and Tecnopolis supporting entrepreneurial development in southern Italy

- Business Management Training School (SPEGEA) - advanced training for management personnel of private and public companies, service organizations, and public administrators
- School for Advanced Studies in Industrial and Applied Mathematics (SASIAM) - advanced training in industrial mathematics
- Advanced School for Mastering Information Technologies (ASMIT) - training of executives in integrating financial and administrative skills with technical knowledge
- Various cooperative work units with Italian companies
- New entrepreneurial initiatives created by young researchers based on new scientific results
- Circolo Dell'Affidabilita - collecting, processing, and distributing data regarding electronic components reliability
- Center of Diagnostic and Quality Assessment for electronic components
- NETSIEL - planning and realizing information systems and products, and research addressed to the realizing and testing technologies and products for software production
- A working group for organizing cultural and scientific programs of the TECNORAMA UFFICIO exhibition organized by the Fiera del Levante of Bari.

The laboratories available at Tecnopolis include

- Computer-aided design/computer-aided manufacturing
- Computer-aided instruction/computer-aided learning
- Robotics
- Artificial intelligence
- Image processing
- Microelectronics
- Telematics
- Territorial informatics and office automation.

School for Advanced Studies in Industrial and Applied Mathematics

The development of SASIAM arose from several needs. One was the observation that while there were adequate numbers of researchers at the university and industrial level, there was a shortage of persons able to apply mathematical techniques to various technical fields, such as design and production, land resource analysis, environmental impact evaluation, and management in public and private sectors. The SASIAM was planned, as part of Tecnopolis, to bring development in higher level industries to the southern part of Italy. Thus, in addition to the other computational facilities, Tecnopolis has classroom space and a computer laboratory (built around two IBM RT PC machines, networked with microcomputers and terminals) used by SASIAM. The laboratory is connected to the mainframe computers at CSATA.

Dr. Vincenzo Capasso, SASIAM's director, and Dr. Rossana Caselli were my hosts for my Tecnopolis visit. The SASIAM was carefully planned from the outset, and is advised by an executive committee consisting of an international group of well-known mathematicians. The present executive committee consists of Capasso; Carlo Cercignani, Politecnico di Milano, Italia; David G. Crighton, Chairman, University of Cambridge, U.K.; Bruno Forte, University of Waterloo, Canada; Jacques Louis Lions, College de France, France; and Ivar Stakgold, University of Delaware. The school has several activities, including the postgraduate program, special courses, research projects, and summer schools. The school also maintains a library of commercial and internally developed computer software, publishes the lecture notes from courses taught there, and contributes editorial support for the Journal of Industrial Mathematics. Since it is an international program, English is the official language. I will discuss the educational activities in more detail.

The objectives of SASIAM are

- To develop a center of expertise in Applied Mathematics at an international level
- To create, through a postgraduate program, a "Mathematical Engineer," which more nearly corresponds to the new professional role of the Industrial Mathematician
- To offer educational activities of high specialization to researchers and technicians already employed
- To spread knowledge of Industrial Mathematics in the southern Italian and Mediterranean universities
- To implement a library of mathematical software specifically dedicated to industrial needs
- To organize, promote, and stimulate educational activities and exchanges with universities and European Economic Community industries.

The program at SASIAM is two or three years long, depending on the type of certificate to be awarded. Students come to SASIAM after obtaining their first university degree in disciplines such as Computer Science, Engineering, Physics, Mathematics, or Statistics. Students may come after employment in industry or at universities. There are two years of formal coursework, including four core courses, two courses chosen from several, and two courses related to the student's thesis work. Each course consists of 40 hours of lecture and 40 hours of laboratory work. The school year consists of two 8-week terms and a summer session during which the student participates in industrial projects. These projects

are modeled on the very effective "Math Clinic" at the Claremont Schools, Claremont, California. After successfully completing the coursework the student receives a Certificate of Expertise in Applied Mathematics. The thesis is based on the student's contribution to a joint research project carried out between the school and an industrial, governmental, or applied research center. The candidate's participation is jointly supervised by the thesis advisor and a person from the organization originating the project, where the student will ordinarily work during this period. Each project is developed by a group of no more than four students and is overseen by the two above advisors and a consultant who has experience in solving problems for similar projects. After completing the thesis and an oral defense, the student is awarded a Certificate of Expertise in Industrial Mathematics. The program also qualifies the student to receive the certificate awarded by the European Consortium for Mathematics in Industry (*ESNIB* 89-01:28-31).

The school is, by design, very small and selective. Now about 10 graduates per year are envisioned, with 15 being the maximum. Students are generally expected to attend the school full time and to reside at Tecnopolis for the 2 years of coursework, although employed students can be admitted as part-time students. Decisions on such matters are made on a case-by-case basis. One potential problem is that the school is meeting such a pressing need that industrial employers are anxious to hire the students even before they have completed the requirements for the certificates.

The short (or special) courses are taught by visiting experts at SASIAM. These courses last one week and each day consists of 2 hours each of formal lecture, tutorial activities, and laboratory activities. The dozen courses planned for 1989-90 include finite element methods, logistics, reliability and quality control, and geometric modeling. Summer schools are held at Tecnopolis, usually organized by outside persons or organizations, with SASIAM providing facilities, but no personnel.

Another of the ways SASIAM bridges the gap between university and industry is through the retraining of persons already working in industry. This program is served mainly by the short courses and the summer schools, but if employers agree, it is possible for their employees to attend the regular courses also.

Conclusion

Tecnopolis is an interesting and successful attempt to bring more industry to southern Italy, and to reshape existing industry to be more technically oriented. The SASIAM plays a role in this by training students to solve problems of an industrial nature using analytical and computational tools that are available, but for which the necessary expertise to use them is not.

MECHANICS

The XVIIth International Congress of Theoretical and Applied Mechanics

by David Feit, Liaison Scientist for Acoustics and Mechanics in Europe and the Middle East for the Office of Naval Research European Office. Dr. Feit is on leave from the David Taylor Research Center, Bethesda, Maryland, where he is a research scientist in the Snip Acoustics Department.

Introduction

Although an article on the XVIIth International Congress of Theoretical and Applied Mechanics (Congress) has already appeared (*ESNIB* 89-03:24), a meeting of such size and importance can easily justify an alternative, but not necessarily contradictory, summary. The meeting was held August 21-27, 1988, in Grenoble, France, under the auspices of the International Union of Theoretical and Applied Mechanics. Approximately 30 institutions and companies provided financial support to the meeting. For the most part, these were French organizations, except for the International Center of Scientific Unions, the Robert Maxwell Foundation, and the Office of Naval Research European Office. Except for the years of World War II, these meetings have taken place every 4 years, the first being held in 1924 in Delft, the Netherlands. Such meetings bring together scientists from the entire world helping to promote the development of mechanics as a scientific discipline.

Locale

Grenoble, having a population of 400,000 (including suburbs), set within the heart of the French Alps, stands next to Paris as a center for scientific research. Close to 10,000 of its inhabitants are employed at the numerous high-technology laboratories and universities in the area. The Institut de Mecanique de Grenoble (Institute) is a joint laboratory of the Universite Scientifique Technologique et Medicale de Grenoble and Institut National Polytechnique de Grenoble specializing in the field of mechanics. Institute personnel organized this very well-run and superbly planned meeting.

The meeting was held on the Saint-Martin-d'Heres Campus of Domaine Universitaire, with the scientific sessions held in four different buildings. Because of the distances between the buildings, one could not easily move back and forth between buildings to hear talks at different sessions given in consecutive time slots. Although this was an inconvenience, it is certainly understandable given the large number of participants and papers presented.

Participation and Subject Matter of the Meeting

The statistics of the meeting are truly impressive. More than a 1,000 attendees came from some 45 countries, the largest number coming from France, followed by the U.S. and Great Britain. A fairly large (compared to other international meetings) group of participants (close to 30) came from the U.S.S.R. I have noted such unusually large participation from the U.S.S.R. at several recent meetings. The Gorbachev era of "Glasnost" appears to have been extended even to the U.S.S.R.'s scientific community.

In years past, there were many instances where invited Russian scientists appeared on the published programs of meetings, but unfortunately were not present to actually present their talks. This meeting was quite different; V.I. Arnold, Steklov Mathematical Institute, Moscow, gave the opening lecture entitled "Bifurcations and Singularities in Mathematics and Mechanics." He stated that the foundations of bifurcation theory are derived from the work of Poincare, and to some extent Huyghens, but has advanced notably in recent years because of the recognition of connections between problems of mechanics and certain areas of abstract mathematics such as algebraic geometry and topology, the theories of Lie algebras, and crystallographical reflection groups.

J.W. Miles, University of California, San Diego, presented the closing lecture entitled, "The Pendulum from Huygens' Horologium to Symmetry Breaking and Chaos."

Both the opening and closing talks are related to the fairly new science of *chaos*, which seems to be drawing much attention from the public (Geicke, 1987) and enthusiasm among its scientific proponents (Hofstadter, 1985). Miles' lecture revealed the fascinating range of mechanical phenomena that are contained within the motions of a simple pendulum when the restrictions of linearity are removed. The equations of motion of harmonically driven planar and spherical pendulums are described, together with numerically generated solutions that display the phenomena of symmetry breaking, period doubling, and the transition to *chaotic* motion. In addition to the numerically generated results, he developed analytical approximations for these phenomena. The notions discussed were well-illustrated and fairly easy to grasp since we are all so familar with the linear dynamics of pendula, allowing an easy transition to the world of nonlinear dynamics wherein their bizarre and *chaotic* motions can prevail and are described in the phase plane. He concluded by stating that the very large role played by the pendulum in the evolution of mechanics is matched only by the planets.

In his introductory remarks, Sir James Lighthill, President of the International Union of Theoretical and Applied Mechanics (IUTAM) and the Congress, pointed out the profound changes in our understanding and view of mechanics brought about recently by bifurcation theory, the discovery of strange attractors, and of *chaos*. In addition to these lectures, the meeting included sectional lectures in which recognized experts contributed papers presented either as lectures or in poster-discussion sessions. Three minisymposia were also presented on special topics--mechanics of large deformation and damage, dynamics of two-phase flow, and mechanics of Earth's crust.

In this report, I have concentrated on the highlights of the meeting from my perspective, including the opening and closing lectures, a few of the sessional and introductory lectures that I attended (given the large number of parallel sessions scheduled), and a few contributed papers that I found particularly relevant to structural acoustics.

Sectional Lectures

P.G. de Gennes (affiliation unknown) presented a sectional lecture entitled "Dynamics of Wetting and Drying." This presentation, divided into three parts, offered a mathematical and physical description of what happens when a liquid droplet is spread on a flat solid surface. The first part discussed the final state of wetting, which may result in partial wetting, with a finite contact angle between the fluid wedge and the solid, or complete wetting where a film of fluid forms. In the second part, he discussed the dynamics of an advancing contact line in the

dry spreading of a viscous fluid. In this case, most of the dissipation takes place in a precursor film. The formation of this film solves several theoretical difficulties, one of which is the resolution of a logarithmic singularity in the dissipation. In the third part, he reviewed recent developments on the drying process, the wetting of fibers, and the motion of droplets on a solid surface caused by gradients of the spreading coefficient or temperature. The theoretical developments have significant impacts on several manufacturing processes, and this talk clearly achieved its purpose--introducing and summarizing the state of knowledge in this technologically significant field.

Continuing on with the theme of bifurcation and *chaos* in mechanics, J. Gollub, Haverford College, Haverford, Pennsylvania, discussed bifurcation and pattern formation in fluid mechanics. Gollub collaborated with H. Swinney in the early 1970s to perform fluid dynamics experiments on liquids in flow between two concentric cylinders, one rotating within the other, producing the classic Couette-Taylor flow. As the rotation speed increases, instabilities in the flow begin to appear, ultimately making the transition to what is recognized as a state of turbulence. In this talk, Gollub discussed how bifurcation sequences can be studied experimentally using visualizations on spatially extended fluid systems such as Faraday's interfacial waves, which are driven by the vertical oscillations of fluid in a container. Several dissimilar wave patterns occur that are connected by bifurcation sequences dependent on the amplitude of the external forcing. Gollub demonstrated how the trajectories of the motions can be determined experimentally using a suitable phase space visualization, revealing the various attractors and repellers characteristic of this particular phenomenon.

In particular, the behavior of waves in a square verses a rectangular cell are substantially different, the latter revealing an unusual sequence of bifurcations leading to a *chaotically* varying wave pattern. Work of this type provides an example of the ways *chaos* theory can be derived qualitatively from experimental observations and can ultimately perhaps help fluid mechanicians fathom the complex transitions taking smooth flow into the complexities of turbulent flow.

P. Hagedorn, Institut fur Mechanik, Technical University, Darmstadt, Federal Republic of Germany, discussed the use of active vibration control in large flexible structures. The presentation was very basic and tutorial. He differentiated between two approaches to analyzing such problems. One approach, which he termed as the traditional one, involves the discretization of the structure, as, for example, by finite elements. In this way, the distributed parameter system is replaced by a large set of coupled ordinary differential equations to which the powerful techniques of discrete control theory are applied. The issues of actuator and sensor placement were also introduced.

The second approach discussed was that in which the structural complex is not discretized, but is broken up into smaller subsystems such as beams, plates, and strings, each of which is thought of as a continuous system. The motions of these continuous systems are assumed to consist of traveling waves rather than a superposition of modes, and the control strategies utilized are contrived to absorb energy locally rather than through a global reduction as would be the case in the former approach. The relative advantages of one approach over another is dependent on the size, flexibility, and expected excitation frequency band over which the control is to be achieved.

J.W. Hutchinson, Harvard University, reviewed some of the unresolved issues related to the micromechanics of toughening and resistance to fracture in brittle polycrystalline materials. For ceramics, the mechanisms for such toughening include transformation toughening, toughening by a metal particulate phase, and fiber reinforcement. Hutchinson described some of these mechanisms. Transformation toughening is the result of transformation in behavior that takes place in a two-phase material especially at a microscopic crack tip. This transformation alters the near-tip stress field as the crack-tip advances and leaves behind a wake of transformed material.

In explaining another mechanism, Hutchinson believes that the nucleation of microcracks on the grain boundaries of polycrystalline ceramics arising using small strain elasticity theory, plays a part in the toughening of structural ceramics. Because of thermal anisotropy and the fabrication process, elasticity theory predicts stress singularities at the grain boundary junctions giving rise to the nucleation of microcracks. A cloud of such microcracks can shield a finite-sized crack because of stress redistribution occurring when the residual stresses are released by microcracking. Crack bridging by uncracked grain ligaments helping to lower the intensity at the lead tip of the main crack also plays a part in the toughening. This presentation was unusually clear and was an excellent introduction for the many papers on the mechanics of damage in structural materials.

G.K. Batchelor, Cambridge University, U.K., gave an introductory lecture to the minisymposia on "The Dynamics of Two-Phase Flow;" his talk was entitled, "A Brief Guide to Two-Phase Flow." He called the understanding of such flows "one of the great challenges in fluid mechanics today." In such flows, there are at least two different kinds of matter in relative motion with respect to each other. The different kinds of matter are solid, liquid, and gas representing the different possible states of the matter, or they may differ in terms of their molecular composition.

After describing the many different types of two-phase flow that exist in nature or come about because of man-

made processes, Batchelor defined the various dimensionless parameters that are relevant in the study of such flows. The most important of these are the Reynolds, Froude, and Stokes numbers. He then briefly described some of the qualitative features and gave examples of important flows that were to be the subject of some later talks in the minisymposia. In conclusion, Batchelor warned of the difficulties inherent in understanding two-phase flows. But he added that because of its importance and scientific interest, the difficulties should not deter investigators from going beyond the engineering approach to unravel the obscurity surrounding the relevant physical processes.

The final sectional lecture that I wish to include was by S.W. Kieffer, U.S. Geological Survey, Flagstaff, Arizona, who talked about multiphase flow in volcanic and geothermal eruptions. This talk was previewed by Batchelor as a description of "... one of the most spectacular natural illustrations of two-phase flow, namely a jet of particle laden gas which emerges explosively from an erupting volcano."

It appears that the sound speed of geologic fluids has not been widely recognized, and consequently the significance of supersonic flow in geologic phenomenon has been underestimated. Two examples were discussed.

The first was the lateral blast that occurred at Mt. St. Helens, Washington, where a gas heavily loaded with particles (with a low characteristic sound speed, 100 m/s) was blasted out with a supersonic flow field, subjecting the blast zone to extreme devastation to a distance of about 10 km to the north of the volcano. Kieffer, who was an on-site observer fairly close to the scene, presented spectacular photographs taken during and after the eruption giving vivid evidence of the horrendous forces that nature can unleash.

The second geologic-mechanics description was devoted to the Old Faithful Geyser, Yellowstone National Park, Wyoming. This was modeled as a converging-diverging nozzle in which both single-phase (liquid) and two-phase (steam-liquid droplets) flows are important. This talk, as well as several others, offered a wide range of geological problems offering extreme challenges to the mechanics community in the complexity and richness of the phenomena to be modeled and understood.

Papers Related to Structural Acoustics

Scattered among various sessions, I found a few papers of particular interest to the field of structural acoustics. A.J. Keane and W.G. Price, Brunel University, Uxbridge, U.K., dealt with the issue of the application of statistical energy analysis (SEA) to wave propagation in periodic or near-periodic structures. A usual assumption in the application of SEA is that the probability density function (PDF) of the natural frequencies of a system is taken to be uniform. Because a periodic structure is characterized by pass and stop bands, they display a highly nonuniform PDF. The "enhanced" models used here do not require a major reformulation of the approach, and are also useful for structures exhibiting mild deviations from pure periodicity.

In another session, C. Pierre, University of Michigan, presented a paper on the phenomenon of vibration localization in nearly periodic structures. Several European investigators have studied this problem in the past with very similar results, (Hodges, et al.) Pierre finds that there is strong localization (confinement of the vibrational response) in the vicinity of the excitation when there are slight deviations from periodicity. The idealization used for the study is a set of coupled isolators, loosely modeling the many identical blades of a turbine disk. Quantitative expressions for the localization factors (rates of exponential decay in vibration amplitude away from the drive region) are determined in terms of the standard deviation of the structural irregularities, excitation frequency, and the coupling between the oscillators. Observations of this type of localization are sometimes ascribed to "damping", but this paper examines the different mechanisms of localization and damping.

The paper that immediately followed Pierre's investigated the quality of vibration process localization in semi-restricted regions and was contributed by I.P. Obraztsov, U.S.S.R. National Committee on Mechanics, Moscow, and V.A. Babeshko, Kuban State University, Krasnobar, U.S.S.R. The semi-restricted region referred to here was an elastic layer in which the vibrations induced by forces acting on one face of the layer are localized by the finite thickness of the layer interacting with cracks or inclusions in the layer. Several participants in the audience expressed skepticism with respect to the results, and a final analysis must await a detailed study of the written paper to appear in the proceedings of the conference.

Conclusions

Over a 5-day period, this conference offered more than 500 papers over the full spectrum of both solid and fluid mechanics. Attendees were provided with the opportunity to keep abreast of developments in their own specializations, while at the same time they could venture into new fields through the sessional lectures and introductory lectures to the minisymposia. The choice of special and invited lecturers was excellent; each one that I listened to providing informative and generally understandable introductions to their focused material.

Although the field of mechanics is a classical subject, the range of applications to newer sciences such as geology, the mechanics of materials, and the study of tur-

bulence as so clearly evidenced at this meeting guarantees the continued vitality of the subject in the future. The Proceedings of the Congress have now been published and are available from North Holland Publishing. The next Congress will take place in 1992 in Israel.

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PSYCHOLOGY

International Conference on Models of Brain Function

by Rodney M. Cotterill, Joel L. Davis, and Gerald S. Malecki. Dr. Cotterill is Professor of Biophysics, Technical University of Denmark, and Dr. Joel Davis is the Manager of the Biological Intelligence Program, Cognitive and Neural Sciences Division, Office of Naval Research, Arlington, Virginia. Gerald Malecki is the Liaison Scientist for Human Factors and Behavioral Sciences at the Office of Naval Research European Office and he is on leave from the Office of Chief of Naval Research, Arlington, Virginia, where he is a Scientific Officer in the Cognitive and Neural Sciences Division.

Introduction

The International Conference on Models of Brain Function was held on June 12-16, 1989, at the Gentofte Hotel, Copenhagen, and was attended by approximately 70 people from 11 countries. The meeting, organized by Professor Rodney Cotterill, Technical University of Denmark, included 43 individual presentations. All presentations were oral (rather than by poster), and there was a three-hour panel discussion during the penultimate afternoon. The papers covered six topical areas: (1) organization and structure of neuronal systems; (2) neural processing of sensory information; (3) computational vision; (4) neural mechanisms for motor control; (5) mechanics of neural networks; and (6) diagnostic and therapeutic techniques. The treatment of the topics included theory, mathematical modeling, computer simulations, physiological studies, behavioral experiments and hardware implementation of vision algorithms. The presentations were divided into reasonably well-defined groups, and this report is structured to reflect those classifications. The conference this year addressed models of brain functions in each of three major structures of the brain, namely, the hippocampus, the cortex and the cerebellum.

Presentations

The meeting opened with a presentation by Terrence Sejnowski, The Salk Institute, San Diego, California, of his recent work on associative long-term depression in the hippocampus induced by Hebbian covariance. This discovery was made possible by an experimental approach in which different inputs could be made to the hippocampus slice. Pyramidal cells in the CA1 region of the hippocampus were investigated with stimuli of frequencies at 100 Hz and 5 Hz. The former were used as conditioning input stimuli, while the latter inputs functioned as tests. Remarkably different behaviors were observed in the experimental preparations depending upon whether the conditioning and test inputs were in or out of phase; i.e., whether they were positively or negatively correlated. A brief conditioning input of excitatory synaptic activation produced a long-lasting increase in the synaptic strengths or "long-term potentiation." The test input alone does not produce a long-lasting effect on synaptic strength, but can occur when it is activated at the same time as the other input. In other words, it has an effect if the correlation is positive. Sejnowski had shown earlier that the negative correlation situation should produce a decrease in synaptic strength; this having been indicated by neural network modeling studies. Clear indications were observed that such long-term depression really does occur for the negative correlation situation. These experiments therefore provide striking evidence that synaptic changes can occur in the hippocampus within remarkably short times. The effects were seen for training periods as short as two seconds.

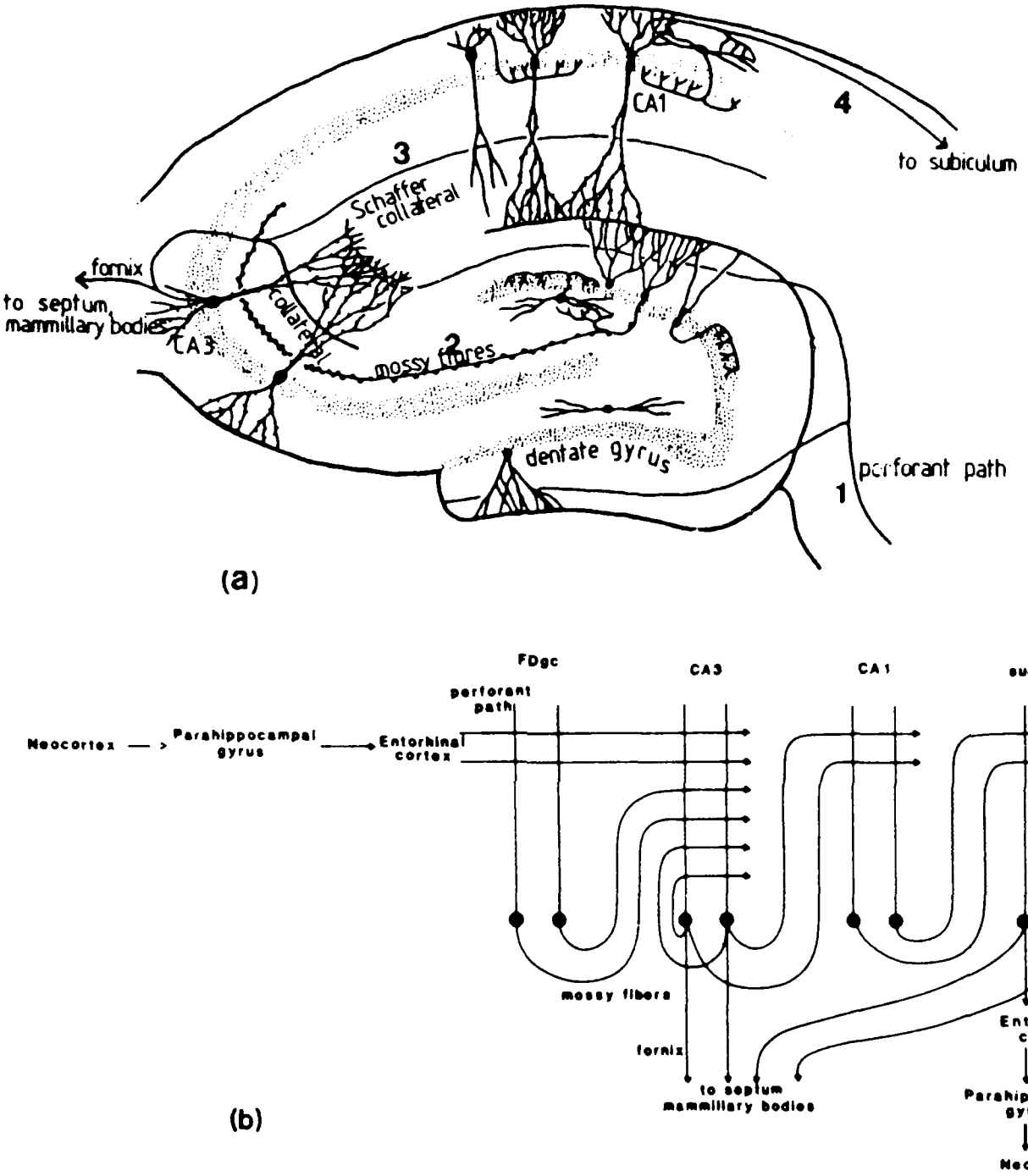
Sejnowski's paper was followed by a presentation on the hippocampus by Edmund Rolls, Oxford University,

U.K. In this presentation, CA3 cells rather than the CA1 cells were the main object of study. The position of both of these cell types in the hippocampus is indicated in Figure 1 (source: Rolls, 1989) which illustrates connections within the hippocampus. As can be seen at the extreme left of the upper part of the figure, illustration (a), the CA3 cells have collaterals that fold back on themselves to produce numerous synaptic contacts with their dendritic fields, producing the type of associative network that has been studied extensively by Kohonen. This is indicated schematically in the lower part of Figure 1, illustration (b). There appears to be reasonable anatomical underpinning for the conjecture that all possible synaptic contacts are in fact present in this system. In other words, the network is of the "all-to-all" type. An important result of this anatomical arrangement in this particular region of the hippocampus is that well-defined features become readily recognizable. One interesting aspect of this work is evidence for an interplay between the hippocampus and two other brain regions--the amygdala and layer 1 of cerebral cortex--and that this plays an important role in the memory recall process. Cortical layer 1 is very often simply not considered as a candidate for anything useful because of the very low density of neurons in that particular cortical region. This work by Professor Rolls and his colleagues suggests that the neglect of this layer could be a serious inadequacy in previous attempts to properly model cortical function.

There was much intellectual food for thought in the work presented by Steven Rose, Open University, Milton Keynes, U.K., and his work strikes several notes of caution regarding brain models that are too simplistic. Rose's experimental work was carried out on newly-hatched chickens. The experimental technique involved coating beads with an aversive chemical, which were then presented to young birds. These beads normally elicit pecking, but aversive coatings rapidly teach the young chicks to avoid pecking. The goal of the investigation was to see whether the birds would associate cause and effect if these were separated by a considerable period of time (e.g. a half hour), in contrast to traditional classical conditioning paradigms which show no associations forming with time intervals of this length. Rose can also produce sickness or nausea in these animals at any time by injecting lithium chloride. The experiments indicated that the chicks can retain a memory of an apparently neutral stimulus for at least a half hour before associating it with sickness. Moreover, in order for the chick to hold on to this memory, it must synthesize membrane glycoproteins, which are involved in the modulation of synaptic connectivity. One conclusion is that the internal representations formed in chick brain are apparently important enough for the chick to devote metabolic resources to the manufacture of new glycoproteins to "code" the bead, even in the absence of a specific aversive unconditioned stimulus. This is a most surprising result, and it is really quite ominous for the type of assumption usually made in connection with neural modeling; namely, that there must be a very tight temporal correlation between the stimulus and the effect. This work has obvious implications for neural modelers to re-evaluate the simple assumptions of Hebbian learning that are usually embodied in their simulations.

There then followed a number of presentations in the general area of vision. Tomaso Poggio, MIT, based his presentation on a number of visual illusions, particularly those that involve motion. From a careful analysis of what is known as the "barber-pole" illusion, in which motion in one direction is perceived by the visual system as motion in a direction lying at right-angles to this, Poggio questioned whether it makes sense to ask what an individual receptor is "seeing". The message of his work is that one is always forced to consider the collective properties of groups of neurons, as embodied in the algorithms of Poggio's own Vision Machine, indeed, and in Anya Hurlbert's (also MIT) work on color vision. This makes possible the segmentation of the (colored) visual image into its component parts. Poggio also described the MIT Vision Machine which incorporates several early vision algorithms that compute edge detection, stereo, motion, texture, and surface color in close to real time. A Connection Machine serves as the main computational engine and the algorithm integration stage is based on coupled Markov Random Field models. This same issue resurfaced during the presentation by Daniel Pollen, University of Massachusetts Medical School, Worcester, Massachusetts. Although the Pollen work included attempts to ascribe filtering properties to single neurons in the primary visual cortex, the properties first emerge when interactions with other cells are considered. By studying the response to sinusoidal grating patterns, Pollen and his collaborators have demonstrated the presence of phase effects which underlie the visual system's remarkable powers of discrimination and perception.

Jerome Feldman, International Computer Science Institute, Berkeley, California, was more concerned with the higher levels of visual processing, and his presentation was primarily couched in terms of conjectured hierarchies of cognition. Feldman paid particular attention to two different effects--one positive and one negative. The former is the observed "capture effect" in which certain features in a visual field are seen to move only if there is a simultaneous provoking motion of another feature. A typical example is the captured motion of a series of dots if there is a moving frame in the same visual field. The negative effect is most illuminating, and it refers to the way in which a partially-illuminated pattern appears to possess all the characteristics of its fully-illuminated counterpart. An example is the visual system's correct interpretation of the movements of a human figure if only



(a) Representation of connections within the hippocampus. Inputs reach the hippocampus through the perforant path (1) which makes synapses with the dendrites of the dentate granule cells and also with the apical dendrites of the CA3 pyramidal cells. The dentate granule cells project via the mossy fibers (2) to the CA3 pyramidal cells. The well-developed recurrent collatoral system of the CA3 cells is indicated. The CA3 pyramidal cells project via the Schaffer collaterals (3) to the CA1 pyramidal cells, which in turn have connections (4) to the subiculum.

(b) Schematic representation of the connections of the hippocampus, showing also that the cerebral cortex (neocortex) is connected to the hippocampus via the parahippocampal gyrus and entorhinal cortex, and that the hippocampus projects back to the neocortex via the subiculum, entorhinal cortex, and parahippocampal gyrus.

Figure 1. Representations of Connections Within the Hippocampus

certain points are lighted with electric bulbs; e.g., a bulb at each elbow, each knee, each wrist, and so on. The remarkable thing is that if either the moving scene or the interpreter is rotated through a half turn (so that what was previously up is now down, and vice versa) the visual system appears to have an extremely difficult time of making the correct interpretation. Feldman thinks that this reveals a great amount about the way in which higher visual processing is carried out.

The final talk in the opening session (major invited presentations) was delivered by Ralph Linsker, IBM, Yorktown Heights, New York. Linsker has made the remarkable discovery that cells in the visual system, which originally have no preference for orientation, spontaneously group themselves to produce extended regions of orientational preference simply through their mutual interactions, coupled with the system's apparent "desire" to increase the amount of information being fed to it. Linsker has carried out extensive computer simulations that demonstrate this occurring, the number of assumptions being impressively minimal; e.g., that the distribution of excitation and inhibition has the shape of the familiar "Mexican hat function." Linsker demonstrates that the naturally evolving patterns of orientational preference agree with what is observed experimentally. On the cautionary side, one should remember that the Linsker model is capable, under certain conditions, of giving quite different patterns; namely, those that resemble the ferromagnetic condition in a crystal. It is perhaps not surprising that the model admits of this pathology, because the mechanism that underlies the evolution of Linsker's patterns does indeed resemble what happens in crystal systems.

Werner von Seelen, Johannes Gutenberg University, Federal Republic of Germany (FRG), and Rolf Eckmiller, University of Dusseldorf, FRG, dealt with various aspects of processing and control. The von Seelen work is interesting because it elucidates how certain abilities arise in the primary visual system, using an approximation in which one considers only the properties of suitably averaged large numbers of cells. This approach explains, for example, how the visual system could function as a looming detector. The approximations involved make it very difficult to gain any insight about how the higher visual processing would be carried out. The Eckmiller work, on the other hand, was exquisitely detailed, but it worked at the level of subsystems rather than cellular assemblies. Even though this work does not claim to say very much about what goes on at the level of the individual cells, the analysis is able to put certain constraints on the way in which things must be happening at the integrated cellular level. For example, Eckmiller concludes that the patterns of connections in the visual system, which participate in the control of gaze, must possess the capacity for rapid modification.

Bernardo Huberman, Xerox Research Center, Palo Alto, California, presented his views on how studies of the brain and studies of advanced computer systems can be mutually stimulating. Huberman drew parallels between large assemblies of cells and what happens in an ecological system. The work already described by Linsker was sufficient motivation for taking the Huberman viewpoint seriously, because the Linsker system can indeed be looked upon as being an ecological microcosm. Huberman still awaits experimental verification; his ideas must, for the time being, be regarded as interesting conjecture.

Motor control was also addressed in a contribution by James Houk, Northwestern University Medical Center, Chicago. Houk's primary concern was the interplay between control mechanisms occurring in well-separated parts of the central nervous system; namely, the primary motor area (which is the origin of the corticospinal pathway) and the upper brainstem (which is the starting point of the rubrospinal pathway). These two components send signals that both impinge upon the cerebellum, and they thereby provide the coordination required for limb movement control. How this is actually accomplished is not known. However, Houk's idea is that motor pattern generators are stored (in the form of "combinatorial maps") in the cerebellum and that these are activated by the simultaneous arrival of signals from the motor cortex and brainstem, a positive feedback mechanism being operative in both routes. For example, Houk's model can explain why cooling of cerebellar nuclei causes a delay in the onset of movements, and it also provides a detailed picture of recovery from lesions in the motor system.

Other papers addressed the important issue of the role of timing in the functioning of neural assemblies both from theoretical and experimental standpoints. Daniel Kammen, California Institute of Technology, Pasadena, California, addressed the issue of how the transmission of a signal through the visual system depends upon the accurate timing of the activities in the various cells of a given cortical layer. The conclusion was that there must be a considerable degree of synchrony between the cells if the signal is to have a chance of getting through. At the moment, this work uses a continuum approximation (the system being set up as a large series of coupled differential equations) but Kammen and his colleagues have plans for repeating this work using discrete neurons. The work presented by Reinhard Eckhorn and his colleagues, Philipps University at Marburg, FRG, was nicely complementary to that of Kammen's experimental measurements using multiple electrodes. This work demonstrates the detection of features by the cortex and requires the existence of a considerable degree of synchrony in the firing pattern of the individual neurons. In fact, Eckhorn and his colleagues feel so confident about this finding that they are tempted to elevate it to a general principle, applicable to the functioning of all other cortical areas.

Leslie Brothers and colleagues, University of California at Irvine, presented the results of a remarkable investigation which demonstrated that the accuracy of the timing of mutely rehearsed exercises is frequently much better than one percent. For example, a conductor might be asked to conduct an imagined orchestra in a familiar piece of music lasting three or four minutes. Brothers and colleagues discovered that the standard deviation for several such rehearsals is often of the order of one second or so, and they think that this leads to the inescapable conclusion that the timing of individual neural processes must be remarkably accurate. Although it is generally believed that there is no central "clock" in the brain, Brothers and her collaborators think that these results force one to re-evaluate this issue. They believe, indeed, that not only is there an organic clockwork mechanism in the brain, but that it is remarkably precise. They have made several suggestions about how such a mechanism could arise; for instance, that it is related to the well-established columnar structure of the cortex.

Particularly prominent among the other major talks at this conference was that of Benjamin Libet, University of California, San Francisco, on his extremely important work regarding the subjective nature of consciousness. Libet has compared the observed sensations produced by direct stimulation of the skin (on the back of one hand) and that produced by direct stimulation of the cortex, at the appropriate point on the somatosensory strip. To begin with, he finds that the latter stimulation must be continued for at least 500 milliseconds in order to produce a conscious sensation, or what he refers to as neuronal adequacy. Libet then probed the effect of applying the two different stimuli either simultaneously or separated by less than 500 milliseconds. One important observation was that if the skin stimulus is followed by the cortical stimulus, within less than 500 milliseconds, the skin stimulus is not observed at all. Libet refers to this as "backward masking." Libet also showed that if the cortical stimulation follows the skin stimulation by only about 200 milliseconds, the observer actually gets the impression that it is the cortical stimulation which was applied first. Libet's conclusion to this observation is that the cortex, in some manner not yet understood, actually refers the sensation back to a time close to the beginning of the 500 millisecond neuronal adequacy period. There is an interesting parallel with everyday experience here. If you touch a hot stove, you withdraw it well before the actual sensation of pain makes itself felt. But you nevertheless get the impression that you withdrew the hand because of the heat. Such backward referral of sensation, as now quantified by Libet, is thus part of our everyday experience, even though its mechanism has not been appreciated until now. One point was raised about this work (and it is absolutely vital to the entire theme of the conference) is the following: the term "direct stimulation to the cortex" has been used in connection with this work, but perhaps that word "direct" is misleading. The point is that neuronal circuits that are not normally involved in the generation of sensation might be activated when one stimulates the actual cortex. It should not be assumed that there would not be additional time delays for this mode of stimulation. Nevertheless, if the results are replicated, one could hardly overestimate their significance.

Among the shorter contributions, special mention should be made of the new work on electroencephalography (EEG) and magnetoencephalography (MEG). In the former, Erol Basar, Medical University of Lubeck, FRG, and his colleagues have made interesting observations regarding the existence of a strange attractor in the averaged response. This attractor appears to have a dimension of between 10 and 12, in normal cases, but it decreases to a value around 5 or 6 for epileptic patients. There has been no promising suggestion yet as to what either the normal or the epileptic dimension might be indicating regarding the underlying behavior of the neural networks. In the MEG work, described by Photios Anninos, and colleagues, Democritos University of Thrace, Alexandroupolis, Greece, there has recently been a most promising and controversial clinical development. Application of a small reversed magnetic field, to the point on the brain that has previously been established as the epileptic focus, has a curative power. Anninos and his colleagues have followed the cases of several epileptic patients over periods of months, and they have shown that periodic treatment; i.e., approximately twice monthly, in this fashion is sufficient to "permanently" relieve patients of the threat of epileptic seizure. It will be very interesting to follow the future course of these important experiments.

This meeting took place three years after a similar conference in Copenhagen (Cotterill 1989), and another is planned for 1992. Since 1986 there has been a profound change in the field of brain modeling. There has been a resolute movement away from over-simplified neural assemblies with their emphasis on physical transparency. These idealized scenarios are being supplanted by models that take the brain's anatomy properly into account. A good example of this, at the meeting, was the contribution by Steen Christensen and his colleagues, Technical University of Denmark, Lyngby. In their work on the primary visual system, each of the six cortical layers plays a different role, and none of the layers can be dispensed with. This trend towards greater realism is increasing the interaction between brain theorists and the neurophysiological community, which now seems to take the efforts of the computer simulators more seriously. We can expect this gradual shift to continue, and by the time the meeting on brain and mind is held in 1992, even psychological issues may be proving to be amendable to quantitative analysis.

The full conference proceedings, with the title "Models of Brain Function," are scheduled to be published in book form during late autumn 1989 by Cambridge University Press.

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Acknowledgment

Permission to use Figure 1 in this report granted by Dr. Edmund T. Rolls, University of Oxford, U.K.

PHYSICS

I.V. Kurchatov Institute of Atomic Energy, Moscow, U.S.S.R.

by Marco S. Di Capua, the Liaison Scientist for Physics in Europe and the Middle East for the Office of Naval Research European Office. Dr. Di Capua is an experimental physicist on leave until August 1990 from the Lawrence Livermore National Laboratory of the University of California.

Introduction

The I.V. Kurchatov Institute of Atomic Energy (Institute), the most important center of the Soviet Union in nuclear science and technology, performs research in applied as well as fundamental science. A descriptive leaflet (in Russian, no date) emphasizes the Institute's activities in nuclear energetics, nuclear power generation and cogeneration, shipboard nuclear propulsion for transport and icebreaking, research reactors, controlled thermonuclear fusion, inertially confined fusion, nuclear physics, nuclear chemistry, and isotope research.

According to the leaflet, Igor Vasilievich Kurchatov established the Institute in March 1943 to restart nuclear research in the U.S.S.R. In 1944, 3.3E + 12 atoms of Pu became available; in 1946, the first reactor achieved criticality; in 1947, significant quantities of Pu were available; in August 1949, the U.S.S.R. tested its first fission device (Pu), in 1953, the first boosted device, and in 1955, the first multistage thermonuclear device (nn, 1989).

Reviewing a recent anthology of memoirs about Kurchatov (Aleksandrov, 1988), who died of cancer in 1960 at age 57 and is buried in the Kremlin wall, Kuchmnent (1989) says: "Kurchatov ... was a first rate physicist who combined qualities of J. Robert Oppenheimer and Edward Teller. This blend allowed him to find the right language for dealing with such disparate personalities as his Soviet colleagues, captive German nuclear physicists, marshals of the Soviet Army and such *tough cookies* as Stalin and his *henchman* Lavrenti Beria, overlord of the Soviet Atomic project (italicized words are author's)."

According to a recent report in the New York Times (Keller, 1989), Kurchatov also established the Pu production facilities in the Kyshtim Industrial Complex, east of the Ural Mountains, on the shore of Lake Irtyash. He is honored as a national hero by a two-story stone likeness in the center of town. V. Chertkov, the first Soviet journalist to visit the complex in March 1989, has been quoted in the Washington Post (Smith, 1989) saying: "Beria was the Satan who ruled things here. It was he, namely, who was responsible for building the facility at the cost of many lives."

I include these notes because even up to a few months ago, this effort in the U.S.S.R. was shrouded in mystery. As the references show, many veils are being lifted and now we can begin to understand these institutions within their historical context.

Our delegation split into two groups for the visit to the Kurchatov Institute. One group went to the Troitsk branch at Krasnaya Pakra, 40 km from Moscow, while the other visited the headquarters in Moscow.

The Visit to Troitsk

The Troitsk group visited the high field Tokomak T-14 (also called TSP, the Russian acronym for high field Tokomak) and the megavolt pulsed power accelerator com-

plex Angara 5. I did not participate in the Troitsk visit. However, Dr. Anthony Hyder, Auburn University; Dr. Robert Commiso, Naval Research Laboratory, Washington, D.C.; Hugh Kirbie, Lawrence Livermore National Laboratory; and Dr. Regan Stinnett, Sandia National Laboratories, Albuquerque, were kind enough to share their impressions with me. The interpretation of their thoughts is entirely my responsibility.

The High Field T-14 Tokomak

Dr. E.A. Azizov, project leader, conducted the T-14 visit and described the philosophy behind the high field Tokomak approach of the T-14 (mean major radius = 1.6 m before compression, 0.42 m after compression; minor radius = 0.32 m before compression, 0.125 m after compression; B toroidal = 2 T before compression, 13 T after compression). To produce the toroidal confinement field, T-14 has 32, 30 cm-thick, 5 m-diameter single turn chromium bronze alloy coils spaced about 50 cm apart at the outer perimeter. The coils attach to a high strength steel annulus that carries the hoop loads. The toroidal field, 2 T to begin with, will reach 13 T in the plasma after compression and 22 T at the surface of the coils. The toroidal current, which is initially 1.2 MA, is expected to reach 25 MA.

Four 1-MW, 20-MHz radiofrequency antennas provide ion cyclotron resonant heating for the plasma. The antennas will operate at 10 kW cm^{-2} which is about 10 times the power density of conventional antennas. The 2-MW neutral beam injectors will be ready early next year. These sources prepare the 1-keV, 5.0E + 14 cm^{-3} plasma for the adiabatic radial and toroidal compression heating (ATCH) to ignition conditions. The ATCH utilizes imaginative inductive storage and pulse power technology.

The ATCH of the plasma to thermonuclear conditions takes place, through reduction of the major and minor torus radii, in two stages. In a first stage, a rapid excursion of the toroidal field compresses the plasma reducing the minor radius. A subsequent excursion of the poloidal field compresses the plasma simultaneously in the major and minor radial dimensions.

The toroidal field coils are energized with a transformer-coupled 900-MJ inductive store with a primary current of 130 kA and a 850-kA secondary current (7:1 ratio) at the time of maximum compression. The connection of the coils will result in a maximum toroidal current of 29 MA. A thyristor-switched, motorgenerator set feeds the series connection of the eight primary sections of the transformer/inductive store.

Energy transfer from the transformer/inductive store primary to the toroidal field coils takes place through eight two-stage opening switches. The first stage, whose 150-kA conductive phase lasts 10 s, is a compressed, air-driven, accelerated hammer switch that opens in 1-10 ms, transferring the current to a fast explosively driven switch that opens against 40 kV in 100 to 300 μs.

The motorgenerators are the inertial energy store at the heart of the system. Their application follows a long U.S.S.R. tradition, that began with P. Kapitza (Titov, 1987), to produce pulsed magnetic fields with rotating electrical machinery. The T-14 has four 270-MVA units with 960 MJ of stored energy each. These units can deliver 1.9 GJ in 5 seconds to the magnetic field loads with a 30 percent rundown from 3,000 RPM.

A brief description of some of the T-14 pulse power systems appears in a recent book on the physics and technique of powerful impulsive systems (Velikhov, 1987).

The T-14 now operates with a 1-T toroidal field and should attain close to keV temperatures, in preparation for compression, this year.

The Megavolt Pulse Power Accelerator Complex Angara 5-1

The Angara 5-1 accelerator complex is a research facility to perform research on power compression (in time) and focusing (in space) for inertial confinement fusion (ICF). The Angara 5-1 achieves the final power compression by imploding plasma liners, with Lorentz forces originating with powerful short pulses of electrical current. For the initial power compression DC-charged Marx generators in the periphery of a circle, pulse charge spoke-like water dielectric pulse forming lines that inject a short (70 ns), high current (6 MA), high voltage (1.35 MV) pulse into a vacuum transmission line that feeds the imploding plasma liner at the center of the circle. A detailed description of the Angara 5-1 components follows.

Marx Generators and Water Dielectric Pulse Forming Lines. The design of the Angara 5-1 facility at Troitsk called for eight, 2-Ω, 75-kJ, 1.5-TW modules. The 20-m long, 3-m diameter modules, are the spokes in a circle with an overall diameter of 50 m. As designed, 15-stage, 190-kJ Marx generators (@ 75-kV charging voltage) pulse charge a 2.4-m diameter water Blumlein circuit in 1.5 μs with 80 percent efficiency in each module. Five V/n gas switches form the pulse in the Blumlein and synchronize the modules. The interval between module pulses is acceptable (6 to 12 ns jitter) on 70 percent of the shots. Gas prepulse switches in the modules, add another 5 ns of jitter. Each module has two diverter switches that fire with a command trigger 80 ns after the main switches, grounding the intermediate conductor of the Blumlein through 3 resistors. These diverters prevent damage of accelerator components arising from late water breakdowns.

Water breakdown and decreased reliability of the Marx systems above 60-kV charge have taken a severe

bite from the output power of Angara 5-1 specified in its design. The output power into an inductive load was expected to be 9 TW which is only 75 percent of the sum of the power of the modules. It is now 6 TW with 1.35 MV (instead of the 1.8-MV design value) in the 2-Ω output line (60-kV Marx charge). The facility delivers a 6-MA, 70-ns pulse into a short circuit load with 600 kJ of energy at the time of current peak.

The Vacuum Region. A 1.2-m mean diameter, 30-nH, 65-kV cm^{-1} stacked (multi-ring) insulator, separates the water dielectric and vacuum regions of the modules. Coaxial magnetically insulated vacuum transmission lines (MITLs) undergo a transition to parallel plate transmission lines which join to anode and cathode disk current collectors. Two geometries were tried. In one geometry, the MITL diameter and gap decreases along the direction of pulse propagation and the MITLs join in a collector close to the load. In the other, the MITLs begin their transition far away from the collector joining it at a 40-cm radius. It appears that the efficiency of energy transport for either geometry is about 80 percent (Grabovsky, 1988).

The Data Acquisition System. The data acquisition system, supervised by V. I. Zaitzev (Zaitzev, 1989), appears to be very elaborate. There are two screen rooms, one devoted to accelerator control with about 150 digitizing channels for pulses in the 0.05-1.0 μs range. A computer system processes the accelerator data. The data from the experiment is acquired in the other screen room with digitizers as well as 3-GHz oscillographs that have fiber optic displays with 15-μm fibers that couple light directly to photographic film.

Experiments. In a first group of experiments, Angara 5-1 delivered currents of 3 to 4 MA to imploding Al, Cu, and W multiwire shells (6 to 24 wires) that simulate cylindrical liners with initial radii of 0.4 to 1.5 cm, heights of 1 to 3 cm, and linear mass densities of 1 to 2.0 E-04 g cm^{-1}. The wire shells, compressing to a 1-mm diameter column, converted 20 to 25 percent of the Angara 5-1 energy into 100 kJ of vacuum ultraviolet and soft x-ray radiation with up to 24 kJ in the Al K_α line and 20 percent of the total yield above 2 keV.

Plasma erosion opening switches are used successfully in the wire shell experiments to improve trapping of the electron flow and to reduce the effects of asynchronism of the modules (Velikhov, 1989). The switch, located at a radius of 50 cm, conducts 2 MA before opening with current rise rates of 1.0E + 14 A s^{-1} allowing a current rise of 3.5 MA to the wire load in 30 ns. Twenty-four plasma sources fire 30 cm away from the power feed, 8-10 μs before the power pulse. A 1.5-μf capacitor charged to 25 KV delivers a 30-kA pulse with a 2-μs risetime to each gun.

The N_2 and Xe gas puff implosions (R = 1 - 1.5 cm, L = 1.0 cm) onto a 2-mm core have been performed, as well as D_2 pinches to determine the scaling laws and the mechanisms of neutron production (1.0E + 12 neutrons with currents of 1.6 - 1.8 MA). Indirect drive target experiments have also been performed, but no details were given except for a mention that the targets would be utilizing the Mokov pressure drive, a term I am not familiar with.

Diagnostics. Grabovsky (1988) and Velikhov (1989) describe the x-ray diagnostics in detail. The x-ray spectral data appears to be all time-integrated.

Future Plans. An ion beam driver upgrade is planned with 6-MV, 6-TW, 6-Ω output. The design for this oil facility, to fit in the same building and to be called Angara 5-M (m is the initial letter for oil in Russian) is now complete. However, there are no funds allocated at present for the upgrade. A high priority in V. Smirnov's agenda is to build two modules to prove the design.

The Kurchatov Institute

Our visit to the Kurchatov Institute headquarters was a very pleasant event. Our hosts, researchers very much like us, were interested in a genuine exchange of technical information as well as in our personal points of view on research programs. The Angara 5-1 module (AN 5-1) was well prepared for our visit. The hardware was open for viewing, allowing plenty of time to discuss experimental results and planned experiments.

Pulse Power Current Transformers

The most interesting piece of hardware on display was a transmission line transformer that converts the 2-Ohm output impedance of the generator into 0.04 Ohms. The transformer consists of 48 2-Ohm water-dielectric coaxial transmission lines, distributed in 6 concentric circles of 8 lines each, connected in series at the input and in parallel at the output. Each 2-Ohm transmission line has its own acrylic water vacuum interface that will operate at 300 kV. Sixteen magnetically insulated parallel plate collectors lead the current into the central liner load. In a recent publication, Bulan describes a half-scale version of the transformer that has been tested on AN 5-1 (Bulan, 1988). The larger version is already installed on AN 5-1 and is ready for testing. It is expected that the full scale transformer will deliver about 3 MA at voltages of about 120 kV.

This appears to be a convenient arrangement to convert older coaxial water-dielectric 2-Ohm-like relativistic electron beam accelerators into low-impedance liner drivers. As a nice feature, this transformer allows an easy parallel connection of the coaxial outputs into collector plates to feed liner loads. The geometry lends itself to implementation of erosion switches as well. A drawback of

the transformer is the amount of energy stored in the stray capacitance between the outer conductors of the transmission lines.

A magnetically insulated vacuum transformer that was seen for the first time during a Megagauss 3 institute visit 6 years ago (Demeter, 1983), has finally appeared in the Soviet literature (Bulan, 1988a). The primary of the transformer forms a loop that connects the center conductor and the outer conductor of MITL. Multiple secondaries fill the center of the loop and connect in parallel to an inductive load. N. Yugami (Yugami, 1988) reported results with a transformer of a similar geometry at Beams '88.

Bulan tested a half-scale model of a transformer intended for AN 5-1 on a 400-kV, 2.3-Ohm generator and measured the input and output currents as well as current losses as a function of spacing between the primary and secondary windings, suggesting that there is a minimum spacing (about 6 mm) in their experiment beyond which the electron losses become unacceptable. It is not clear whether these losses are associated with the onset of field emission or with a loss of magnetic insulation. It would seem that, given the complicated field geometry, and experiences at other laboratories with electron losses at impedance discontinuities, that magnetic insulation in the transformer geometry would be difficult to maintain.

Implosion of Z-pinches with Embedded Fields

Results from an experiment on the stabilization implosion of plasma liners with embedded magnetic fields stimulated very lively discussions. This experiment, performed on AN 5-1 by E. Gordeev using the transmission line transformer (U = 150 kV, Z_{source} = 0.04 Ohms, I_{max} = 2.5 MA) described in the previous section, had an unusual gas puff liner geometry (length = 1 cm, diameter = 3.5 cm) (Gordeev, 1989). The maximum axial field, applied with external coils was 1 T. Without an axial field, x-ray framing images reveal an m = 0 instability. With an axial field, the striations in the emission appear inclined to the axis suggesting that the conduction electrons are frozen in the magnetic field. An experimental result that corroborates this interpretation is that the inclination of the striae changes by 90 degrees when the applied field reverses. Axial fields above 0.5 T prevent collapse of the shell and the x-ray emission intensity associated with the minimum radius of the shell decreases substantially. Of great interest, of course, are experiments that will be performed with the full-scale transformer at a current of 3 MA.

Dense Pinches Resulting from Explosion of Thin Wires

S. Bogoliubsky has utilized the current transformer to drive a thin wire in an attempt to obtain radiation collapse (Robson, 1989) along the whole length of the wire. The experiments involved traditional x-ray diagnostics and electrical measurements. Tungsten L_α radiation and Copper K_α radiation reveal a nonradiating core that could be either an unexploded part of the wire or a cool, dense, weakly ionized plasma at the axis of the plasma channel. This heterogeneous distribution precludes observation of the radiative collapse.

Bogoliubsky has also observed "hot points" that evolve from ring-like structures that form along the discharge channel. These structures collapse into small, very hot sources of x-ray emission. At the moment, it is difficult to say whether the hot points are a nuisance or whether they can be effectively exploited in inertially confined fusion arrangements. A simple guess is probably the former.

Stand 300

The last installation we visited was Stand 300, a 10-TW, 3.2-MV facility under construction, intended as a nuclear weapons effect simulator, an implosion driver, and possibly as a driver for ion diodes. This facility has eight 300-kJ, 1.2-Ohm vertical modules that incorporate 3.5-MV oil insulated Marx generators and water dielectric transmission lines. All interfaces (oil/water and water/vacuum) lie in the horizontal plane. Convolution of the outputs will take place in vacuum with a projected inductance of 8 nH. The structural components of the Marx generators (Fiberglass-Epoxy) displayed an extraordinary feat of large-scale machining. I did not see any of the water line components or the vacuum interfaces. A. Chernienko, the designer of the water/vacuum interfaces, is not worried about gas bubbles collecting on interface surfaces or water/oil mixtures resulting from diaphragm failures.

Conclusion

In a very relaxed atmosphere, our Soviet colleagues discussed their successes as well as their disappointments. They shared with us some of their preoccupation with new funding directives that require justification of projects on a yearly basis, and shrinking defense appropriations that result in budget cuts for pulse power installations.

In the case of the T-14 Tokomak, Kurchatov is reaping the harvest of a visionary program, pioneered by E. Velikhov and A. Sakharov, on inductive storage system technology and flux compression.

The transmission line transformer on AN 5-1, provides Kurchatov with a power source of extraordinary low impedance. This source may open new frontiers on the physics of imploding liners and may provide new insights on the physics of ultra-low impedance, short pulse, pulse power systems.

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The Institute for High Temperatures of the U.S.S.R. Academy of Sciences

by Marco S. Di Capua

Introduction

I visited the Institute for High Temperatures (IVTAN) of the U.S.S.R. Academy of Sciences (Academy) as part of the scientific itinerary of a group of 20 U.S. scientists attending the Novosibirsk Opening Switch and Megagauss V meetings in early July 1989.

In his welcome greeting, the Director, M. Brialovich, told our group that IVTAN is one of the Soviet Union's leading establishments in the field of thermal physics and new power generating processes. Located in a Moscow suburb, IVTAN has a total staff of 3,500, of which 1,200 are academicians, corresponding members of the Academy, professors, engineers, and technicians. The IVTAN is quite unique since its research proceeds to development of large scale prototypes that IVTAN "incubates" before transferring them to industry. In particular, IVTAN has an experimental test complex that determines that prototypes to be transferred to industry are ready for production.

Brialovich highlighted several research activities that we would not visit because of a lack of time. Among them:

Physical Properties of Substances at High Temperatures. A large challenge of this traditional area encompasses methods and techniques to accurately and reliably measure the properties of matter at extreme conditions. The IVTAN routinely studies thermophysical and electrophysical materials properties such as heats and temperatures of fusion up to 6000°K, heat conductivities up to 2800°K, thermal expansion and electrical resistivity up to 3600°K and combined heat capacities and heat conductivities from 700 to 1700°K. A highlight is the measurement of the C triple point. In the near future, IVTAN plans to commercialize, in diskette form, thermophysical data that exists currently on a computerized data base.

Heat and Mass Transfer/Physical Gas Dynamics. This section investigates the combined effects of gas dynamic flows and high energy fluxes as well as the production of shock waves at very high velocities. Two examples of these activities are thermal protection of re-entry objects that are subject to very large thermal stresses and hardening of material surfaces with laser radiation. An example Brialovich gave is laser hardening of a 1.5-m-diameter, 20-ton cylinder for a rolling mill.

Magnetohydrodynamic (MHD) Generators/Energy Conversion Technology. The IVTAN developed MHD generators with pulse durations in the 1-10-μs range and powers of 20-50 MW to power electromagnets that generate magnetic dipole fields at the ground surface. Measurements of the dipole electric field that accompanies the magnetic field that penetrates the earth's crust reveal the conductivity of geological structures as deep as 20 km. Some of this work was pioneered at the I.V. Kurchatov Institute of Atomic Energy (see preceding article). While geophysicists may be familiar with this probing technique, I have not seen a reference to this technique in the literature. This technique is under test at research facilities in Central Asia, in the Kola Peninsula, and around Lake Baikal. This activity is highlighted in the bilingual IVTAN brochure.

Applied Aspects of Superconductivity. Research involves magnet development for superconducting inductive energy storage units (SPIN) to damp oscillations in large electrical power grids, and to deliver energy to power grids in short timescales compared to the speed up of rotating generators (Pfotenhauer, 1988). The IVTAN has placed substantial emphasis on creating superconducting inductors with conductor configurations that suppress stray fields outside the inductor. Ten-to 100-MJ units are available at present and 1.0E + 12 - 1.0E + 13 J units are being considered for early next century.

"A visit to the Soviet Union is a rather unusual event for an ONR Europe Liaison Scientist. However, these are unusual times in the Soviet Union...The occasion for the visit was to normalize relations in the pulse power field. Relations were informally suspended when Andrei Sakharov was exiled to Gorky and the Soviet Union intervened in Afghanistan. Now Sakharov is back in Moscow, Soviet troops are no longer in Afghanistan, and the Soviet leadership is blowing refreshing winds from Moscow." In News, Notes, and Abstracts, page 38, Dr. Di Capua provides personal observations from his Soviet trip.

The IVTAN has also developed superconducting magnets for MHD generators. A small explosively driven superconducting system developed 10 MW for 100 μs. A superconducting magnet, that the U.S. gave to IVTAN through a cooperative program in MHD power generation that ran until the late 1970s, provided the fields for a 1.65-MW MHD generator.

Development of a National Energy Plan. The IVTAN is working on the application of solar energy to space heating and heat pumping, investigating technologies that may become economical in the future. At present, the IVTAN's programs emphasize environmental impact of energy generation and the staff formulates environmental programs for the power generation industry. One of the interests of IVTAN is the clean up of SO_x and NO_x from powerplant flue gases through plasma chemistry (electron beams or dilute plasma discharges). According to Brialovich, this approach has a "bright future", circumventing the use of Pt group catalysts. I. Gallimberti, University of Padua, Italy, is developing a similar approach. Plasma chemistry was the subject of a recent symposium organized by M. Capitelli, University of Bari, Italy.

Gas Discharges and Low Temperature Plasmas. This area involves nonequilibrium processes in low temperature and nonideal plasmas, such as the working fluid of MHD generators and gas discharge laser systems.

A Visit to Selected Laboratory Facilities

Dr. Vladimir Fortov, the director of the Center for Thermophysics of Impulsive Loads, guided our group through several facilities, complementing Brialovich's presentation. Fortov, is well known for his work on equations of state (EOS) and on the physics of nonideal plasmas.

Electron Beam Facility. Investigations in this facility study the generation, transport and energy recuperation of an electron beam. The idea is to transport energy across large distances with relativistic electron beams (REB) and at the same time to develop beam technology for material treatment purposes. A 1-Mev, 10-kA, 10-100 μs Marx generator, in a 2.4-m diameter, 8-m long tank energizes the transport section in a floor below. The high-voltage end of the Marx generator had what appeared to be high-voltage isolation filament transformers for the thermionic cathode. I could not identify the configuration of the high-voltage cathode feed.

The 15-m long beam transport section occupied a heavily shielded 15- or 20-m long vault. Weak magnetic fields stabilize beam transport. Details on transport efficiency, beam stability, or the scheme and the efficiency of beam energy recuperation were not given. Another system (300 kV, 10-20 A, 10 μs) transported a 10-A beam in a magnetically guided SF_6 transport system with only 10 mA losses in 30 m.

Thermophysics of Intense Loading. One-stage powder guns accelerate projectiles to study the physics of planar impact on targets. A single-stage powder gun provides velocities up to 1.8 km s^{-1}. Manganin gauges measure the pressure in the sample, interferometry with an Ar ion laser measures the motion of the free surface, and a pulsed x-ray diffraction system measures lattice properties with 10-ns resolution. The work area appears to be similar to Z. Rosenberg's at Rafael Armament Center in Haifa, Israel (Rosenberg, 1988).

The Computer Center. The Computer Center has a 4-MB, 15-Mflop computer that runs hydrocode calculations. The two-dimensional hydrocode has a semi-empirical equation of state that can account for electron as well as radiative transport. We saw results of simulations of

- Compression of D_2 in a conical void resulting from the impact of a 100-ps ion beam on a sector of a spherical metal shell covering the void, reported in 1984
- Oblique impact of an Al plate on a Pb target at 10 km s^{-1}.

In such a short visit, it was impossible to judge the speed or the quality of the physics in the simulations. Benchmark problems would be required to assess the code capabilities against national laboratory codes or commercially available software (*ESNIB* 89-07:38).

Blast Simulator Chamber. The IVTAN has a 6-m diameter, 150-Ton blast chamber, that operates at the 10-kg level, designed to contain the blast of 50 kg of high explosive (HE). Experiments performed in this chamber include generation of pressures up to 2 Mb with flyer plates and determination of EOS for Cu up to 20 Mb with a velocity multiplying scheme that relies upon progressive impact of successively lighter plates. Three-stage multiplier systems provide velocities of 20 km s^{-1} that deliver usable pulse lengths of 100 μs. The chamber has also been used to test small magnetocumulative (MCG) generators. Diagnostics in the facility include:

- Shorting pins
- Laser interferometers
- Fast spectrometers with 10-ns resolution
- Diagnostics for plasmas with electron densities as high as 1.0E + 19 cm^{-1}.

A. Deribas, the head of the Special Design Office of High Rate Hydrodynamics of the Siberian Branch of the Academy, is presently designing, for IVTAN, penetrations for one out of four existing 16-m diameter chambers with 30-cm thick steel walls. The design of this chamber facility, rated for 0.5 - 1 Ton (1000 kg) of HE is complete. Since the chamber will operate within the elastic limits,

no water containment around the chamber will be necessary. The expected cost of the facility is 6 million Rubles.

Rail Gun Facility. We saw a rail gun, similar to devices available in the U.S. and Europe. The gun has a 10-MJ energy store (6-12 kV) that drives a plasma armature with 5 MA at the 5-MJ level. The 1-m long barrel will accelerate 10-g projectiles to 4 to 5 km s^{-1} or 2 g up to 6 km s^{-1} starting with a projectile initially at rest. The gun has copper/nichrome alloy rails and fiberglass/epoxy/polycarbonate insulators. The electrodes are good for only one firing. The biggest experimental difficulties are stability of the plasma armature and restrike at the breech. Experimental studies in the gun facility include shock processes, impact processes, EOS at high-energy densities, and related topics. The setup appeared to be nonfunctional since the energy storage bank was missing several switches.

Exploding Foil Driver. A 1-MJ capacitor bank drives exploding foils to 8 km s^{-1} for EOS work. They hope to reach 20 km s^{-1} to obtain data in the 20- to 30-Mb range.

A Toroidal Autotransformer. The last piece of apparatus we saw was a toroidal autotransformer equipped with explosive opening switches. Eight switches, developed at the Yefremov Institute in Leningrad, interrupt in parallel 100 kA against 30 kV in about 10 μs. The switches reach an impedance of 0.5 Ω into an open circuit load.

Conclusions

The overall impression is one of well-worn facilities. The language barrier and a lack of visual aids, in addition to the inevitably poor acoustics and cramped spaces, handicapped our visit. Since the diagnostic equipment was "thin," I had difficulty assessing the level of research activity in the facilities we visited. Some possibilities that come to mind to explain the lack of equipment are

- In preparation for our visit, the clutter was removed that normally accompanies experiments under execution
- Shortage of diagnostic equipment requires apparatus to be moved from experiment to experiment.

The IVTAN, like the other Soviet institutions, is in the midst of change and has developed a large interest outside its boundaries. As an example, Fortov gave me a short monograph on the application of high current charged particle beams to the generation of high dynamic pressures (Akerman, 1989). This collaboration, between Fortov; M. Basko (*ESNIB* 89-08:57), Institute of General Physics; G. Mesyats, Sverdlovsk branch of the Academy; and L. Rudakov, I.V. Kurchatov Institute (see preceding article) suggests that the work on the physics of high-energy densities cuts across disciplines and institute boundaries.

Judging from the references, the manuscript was probably submitted in early 1987 and underwent a 2-year production cycle, rather typical for preprints in the Soviet Union. Probably because of the rarity of copying machines, preprints in the Soviet Union are the only vehicle that allows a reasonably rapid dissemination of information in rapidly changing fields.

As another example of these new interests, IVTAN is examining joint ventures with foreign companies; four countries were mentioned specifically--Hungary, U.S., Finland, and the Peoples Republic of China.

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Second International Symposium on Polymer Electrolytes

by Dr. K.M. Abraham, Head, Lithium Battery Research, EIC Laboratories, Inc., Norwood, Massachusetts

Introduction

The Second International Symposium on Polymer Electrolytes was held at Siena, Italy, June 14-16, 1989. Organized by Professor Bruno Scrosati, University of Rome, it featured technical sessions involving 49 papers and 120 participants. The modern, high-technology character of polymer electrolyte research pleasantly contrasted the medieval setting of Siena providing an aesthetically appealing forum in which to discuss new results and a fertile atmosphere to foster fresh ideas. The symposium covered virtually all current areas of polymer electrolyte research--from theory and physical properties to new synthesis, new electrolytes, polyvalent and composite electrolytes, interfaces and electrodes, batteries, and electrochromic devices. Most of the significant research on polymer electrolytes is still conducted in Europe, particularly in France. However, research inroads into this field are being made in Japan and the U.S. While the development of all solid-state high-energy density batteries has been a major driving force behind the development of these materials, their future use may include a variety of other areas such as sensors, electrochromic and thermoelectrochromic devices, and solid-state electrochemistry.

Physical Properties

While various theoretical models and experimental data have provided considerable insight into the nature of ionic motion in organic solid polymer electrolytes, a clear understanding of the ionic transport phenomenon in these materials is still lacking.

K. Kakihana, Chalmers University of Technology, Sweden, discussed using optical spectroscopy for polymer electrolyte characterization. Brillouin scattering was employed to study elastic properties and the local chain flexibility of polymer electrolytes. Raman scattering was used to determine the concentration of free charge carriers. Utilizing the CF_3SO_3 anion in $LiCF_3SO_3$ and ClO_4 anion in $LiClO_4$ as Raman scattering probes, Kakihana and colleagues studied the spectra of complexes of poly(ethylene oxide) (PEO), and poly(propylene oxide) (PPO), with $NaCF_3SO_3$ and $LiClO_4$. Raman peaks corresponding to free, complexed, and ion paired salt species were identified.

T.A. Skotheim, Brookhaven National Laboratory, Upton, New York, discussed the application of near edge x-ray absorption fine structure to determine the local structure of polymer salt complexes with PEO-KI complexes as experimental subjects.

S. Greenbaum, Hunter College CUNY, New York, and W.H. Mayer, Max-Plank Institute for Polymer Research, Federal Republic of Germany (FRG) presented papers discussing relaxation phenomena in polymer electrolytes. Other papers on physical properties included vibrational spectroscopic studies of cation effects in PEO metal salt complexes and ESR studies of divalent copper PEO complexes.

Synthesis of Polymer Electrolytes

The synthesis of polymer electrolytes with improved conductivity at room temperature and below remains an ambitious goal of this field. The present theory of ionic motion in polymer electrolytes teaches that the conductivity is related to the large scale segmental motion of the polymer backbone. Higher conductivity may be achieved with polymers having highly flexible backbone, an amorphous morphology, and a low glass transition temperature--Tg. The polymer must also possess electron donating functional groups that will allow them to form complexes with metal salts.

M. Watanabe, Sophia University, Japan, discussed new approaches for the synthesis of new polymers and polymer electrolytes. The poly siloxane polymer--$(-(CH_3)_2SiO-)_n$--has the lowest Tg of any polymer presently known. Siloxane polymers reportedly are sensitive to moisture. With the goal of preparing highly conductive polymer electrolytes, $[-(CH_3)_2SiO-]$-containing polymers are being developed in several laboratories; e.g., S. Kohjiya, Kyoto Institute of Technology, Japan; J. Smid, SUNY, Syracuse; H. Cheradame, École Francaise de Papetiere, France.

Researchers from Warsaw University discussed the high conductivity of PEO-PPO/$LiBF_4$ copolymer complexes. The PEO used in the electrolytes has low molecular weights. The low molecular weight PEO apparently imparts a plasticizing effect. Indeed, it has become standard practice to add low molecular weight polymers as plasticizers into high molecular weight polymer counterparts to obtain electrolytes with higher conductivity. However, in my view, some of the resulting materials are not true solid polymer electrolytes. They have a viscous character that facilitates ionic conduction, but they may be better viewed as viscous liquid or quasi-solid polymer

electrolytes than true polymer electrolytes. K. Koseki, Mie University, Japan, described a practical technique to utilize such quasi-solid electrolytes by immobilizing them in porous membranes such as a porous polyethylene film.

M. Armand, Grenoble, France, one of the fathers of this field, always has something new to report. He reported on a new Li salt, lithium-bis(trifluoromethane sulfone) imide--$LiN(SO_2CF_3)^2$--which, in addition to forming highly dissociated complexes with PEO, apparently imparts plasticity to it leading to high electrolyte conductivity. A conductivity of 5×10^{-5} $(\Omega cm)^{-1}$ has been found for $(PEO)_{30}.Li(CF_3SO_2)_2N$.

S.A. Dobrowski, Sheffield City Polytechnic, U.K., described a new class of electrolytes based on Li salt complexes of poly(N,N-dialkylacrylamide)s.

Polyvalent Ion Conductive Electrolytes

Several research groups presented results dealing with divalent ion-conducting electrolytes. Data on syntheses and properties have been described for Cu, Zn, Ca, Mg, Pb, Ni, Co, Fe, Sn, Cd, and Pb salt complexes of PEO. The major players in this field include University of Pennsylvania; Leicester Polytechnic, U.K.; University of Uppsala, Sweden; Instituto Superior Tecnico, Portugal; and University of St. Andrews, Scotland. I note in this connection that PEO and analogous polymers that contain electron donor groups will form complexes with practically every metal salt. Consequently, the synthesis of new complexes is perhaps less novel than identifying polyvalent ion-conductive electrolytes with unusual properties.

F. Rousseau, Fraunhofer-Institute fur Silicatforschung, FRG, in collaboration with M. Armand, prepared organically modified ceramic electrolytes as solid-state proton conducting materials. Proton conductivity is provided by the amino group in the composite materials. The highest conductivity found at 25°C was 3.3×10^{-5} $ohm^{-1}cm^{-1}$. Possible practical applications of these materials include solid-state batteries, electrochromic devices, and hydrogen sensors.

Applications

The last day of the symposium was devoted to practical applications of polymer electrolytes. Two major applications are in electrochromic devices and solid-state batteries. Professor Deroo, Laboratoire d'Ionique et Electrochimie due Solide, St. Martin d'Heres, France, reviewed electrochromic devices using polymer electrolytes. Potential uses of these devices as displays and light modulators are being pursued in several laboratories in Europe and the U.S. Professor Mino Green, Imperial College, U.K., reviewed optical properties of thin solid film oxide bronzes for electrochromic window applications. He stressed that Li_xMoO_3 provides the best coloration among bronzes and that certain V_2O_5-MoO_3 alloys are highly desirable as transparent counter electrodes.

Studies relating to solid-state Li batteries are being carried out in several laboratories. A. Belanger, Institute de Recherche d'Hydro-Quebec, Canada, reviewed Li electrode behavior in polymer electrolyte cells. He compared elemental Li and various Li-Al alloys as battery anodes. Because of the lower energy density and poor dimensional stability of the Li-Al alloys, elemental Li is preferred as anodes for polymer electrolyte batteries. An efficiency of 99 percent has been obtained for Li cycling at 50-60°C in a Li/TiS_2 polymer electrolyte cell. Typical cycling of cells was carried out at rates of C/16 for charge and C/8 for discharge. The corresponding current densities are 50 and 100 $\mu A/cm^2$, respectively. For cell cycle-life data, they referred to their paper presented at the Electrochemical Society meeting in Honolulu, Hawaii, in October 1987. Y. Geronov, Central Laboratory of Electrochemical Sources, Sofia, Bulgaria, described cycling results for polymer electrolyte cells utilizing $Na_{0.1}Cr_{0.8}V_{0.2}S_2$ and $Li_xCr_{0.8}V_{0.2}S_2$ as cathodes. More than 50 cycles were obtained when cycled at 140°C at 170 μA/cm2. R.J. Neat, Harwell Laboratory, U.K., updated their program on solid-state batteries. A prototype cell was passed around for examination by the audience. However, it was brought up in the presentation and in subsequent discussion that V_6O_{13} may not be a desirable cathode for practical solid-state secondary batteries. This material appears to show fundamental irreversibility with repeated charge/discharge cycles. Based on work I have done on Li/V_6O_{13} liquid electrolyte batteries, I concur with this conclusion. However, the stoichiometric V_6O_{13} with lower specific capacity is highly reversible.

The audience eagerly awaited the paper on the solid-state battery being developed by Mead Imaging, Ohio. A prototype cell shown was a rather sophisticated one--a battery with a total thickness of 100 to 150 μm. The battery is claimed to be capable of discharge performance down to -40°C. The discharge of the cell at room temperature is carried out typically at the 15-h rate. However, it apparently is capable of pulse currents of 30 to 60 mA/cm^2. The nature of the electrolyte in the cell was not disclosed. However, the electrolyte conductivity values presented appeared to suggest that the cell did not utilize a true solid polymer electrolyte. The conductivities of their electrolyte were 5×10^{-3} S/cm at 25°C, 1×10^{-3} S/cm at -20°C and 1×10^{-4} S/cm at -40°C. These values are very similar to those of a 1 molar solution of $LiAsF_6$ in propylene carbonate or a similar organic solvent. Whether or not Mead has a true solid polymer electrolyte battery remains unresolved. However, the thin film battery technology they reported was extremely impressive and may find a variety of applications.

Final Impressions

I came out with the feeling that the field of polymer electrolyte research is a highly active one. Improved understanding of the phenomenon of ionic transport in solid polymer is being gained via better theoretical models and new experimental data for a variety of polymers. Progress is being made in synthesizing polymer electrolytes with high conductivity at or near room temperature. While progress in practical device development has been slow, potential applications of these interesting materials are certain to multiply with the kind of attention they presently draw.

This report will be incomplete without the mention of the research being carried out in our laboratory. Our work is concerned with the development of dimensionally stabilized, highly conductive, MEEP-based electrolytes. The two classes of composite electrolytes we have developed are MEEP/PEO-$(LiX)_n$ and MEEP/PPO-$(LiX)_n$. The 70 MEEP/30 PEO-$(LiBF_4)_{0.13}$ film has a conductivity of 3×10^{-5} $(ohm.cm)^{-1}$ and the 80 MEEP/20 PPO-$(LiBF_4)_{0.26}$ electrolyte has a conductivity of 4.2×10^{-5} at 50°C. The Li/TiS_2 cells employing these electrolytes are presently being cycled.

The next meeting will be organized by Professor M. Armand and held in France in 1991.

NEWS, NOTES, AND ABSTRACTS

Conference on Parallel Processing

Mr. Gerald S. Malecki

Topic: International Conference on Parallel Processing in Neural Systems and Computers

Dates: March 19-21, 1990

Location: Dusseldorf, Federal Republic of Germany (FRG)

Conference Language: English

Topics

- New Concepts in Computational Neuroscience
- Massively Parallel Computers (e.g., SUPRENUM, Transputer Systems)
- Structure and Function of Biological Neural Systems
- Self-Organization versus Programing in Parallel Computers
- Optical Computers and Molecular Computers
- Parallel Processing in Artificial Intelligence

Activities

- Invited lectures
- Oral presentations
- Poster presentations
- Exhibition of books, neural systems, and computers

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European Conference and Workshop on Computer Vision

Mr. Gerald S. Malecki

The first European Conference on Computer Vision will be held on April 23-25, 1990, in Antibes, France. On April 26-27, there will also be a companion workshop featuring the European Strategic Program for Research and Development in Information Technologies (ESPRIT) activities in computer vision organized by the Commission of the European Communities.

The Conference Scientific Program will include consolidated research results (long papers) and projects describing promising ideas and preliminary results (short papers). The topics include: Active Vision; Color; Motion-Stereo Cooperation; Neural Nets As Applied to Vision, Object Identification, Shape, Texture, and Hardware Architectures. The conference will be organized and coordinated by Institut National De Recherche En Informatique Et En Automatique (INRIA), Sophia Antipolis. O. Faugeras, INRIA Sophia Antipolis, is Conference Chairman. For additional information contact:

Madame Juncker
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Telephone: (33) 93 65 78 60
FAX: (33) 93 65 77 66

The computer vision workshop will be a platform for the presentation and discussion of results of research and development projects pursued under the ESPRIT Basic Research Action. P. Van Hove, ESPRIT/IPS, Brussels is

Workshop Organizer. The attendance will be limited; for additional information, contact:

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Symposium on Physical Acoustics

David Feit

A Symposium on Physical Acoustics, Fundamentals, and Applications will take place in Kortrijk, Belgium on June 19-22, 1990. The main topics are:

- Acousto-optical and photoacoustical problems
- Surface-acoustic waves
- Reflection, refraction, and scattering of acoustic waves
- Inhomogeneous and heterogeneous waves

Authors are invited to submit papers on those topics. Invited papers by internationally recognized experts also will be presented at the symposium.

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Anti-Noise Report in the U.K. Press

David Feit

In a report published in the London Times, the headline read "Britain flies anti-noise plane." The article reports that British engineers have developed and successfully used a system that is able "to cancel much of the engine noise." The system, developed by a team of engineers from the Southampton University's Institute of Sound and Vibration Research and the British Aerospace Corporation, was said to reduce noise in the passenger cabin by more than half.

The same article goes on to discuss another anti-noise project in which a Cambridge-based company has demonstrated a car with an electronic "anti-noise" device used to reduce the sound. Although not mentioned in the article, I believe the Cambridge-based firm is Topexpress Ltd.

Both of these projects were discussed in papers presented at the spring 1988 Institute of Acoustics meeting held at the University of Cambridge (*ESNIB*-89-08). The news article credits the funding of the British Aerospace project to the British Department of Trade and Industry. Fuel efficiency considerations are promoting the increasing use of propeller-driven aircraft, especially for short-haul flights. The propeller blade passage frequency noise and its harmonics can become extremely annoying within the cabins of such planes.

This type of publicity on the use of active control for the reduction of noise pollution is further evidence of the significance with which this technology is viewed in the European community.

Notes About My U.S.S.R. Visit

Dr. Marco S. Di Capua

On pages 27-34, see Dr. Di Capua's discussions of his visits to the the Kurchatov Institute of Atomic Energy, Moscow, and Institute for High Temperatures of the U.S.S.R. Academy of Sciences.

Introduction. A visit to the Soviet Union is a rather unusual event for an ONREUR liaison scientist. However, these are unusual times in the Soviet Union, so I spent 2 weeks as a paying guest of the U.S.S.R. Academy of Sciences (Academy). The occasion for the visit was to normalize relations in the pulse power field. Relations were informally suspended when Andrei Sakharov was exiled to Gorky and the Soviet Union intervened in Afghanistan. Now Sakharov is back in Moscow, Soviet troops are no longer in Afghanistan, and the Soviet leadership is blowing refreshing winds from Moscow.

Background. A concrete result of these changes was the visit of a Soviet delegation to pulse power laboratories in the U.S. in May 1989. The visit coincided with Soviet participation at the Laguna Beach Z-pinch and at the Buffalo Institute of Electrical and Electronics Engineers Plasma Science meetings. The visit was also an occasion to encourage U.S. participation at two back-to-back meetings--an International Workshop on the Physics and Technique of High Power Opening Switches (Novosibirsk, July 1-2, 1989), and the 5th International Conference on Megagauss Magnetic Field Generation and Related Topics (Novosibirsk, July 3-7, 1989). These two areas are a subset of physics of high energy density research where sporadic individual contacts have been maintained throughout the years, notwithstanding the possible application of these topics in areas of national security.

Our Hosts. Our host, Vitaly Bystritskii, Institute of High Current Electronics, Siberian Branch of the Academy at Tomsk, organized the visit with wholehearted sup-

port from Gennady Mesyats, a vice president of the Academy who now directs a new institute of the Academy's Ural branch. Some of Mesyats' U.S. colleagues maintained contact with him during the freeze so this invitation was a gesture to thank his U.S. counterparts and perhaps to show the Academy leadership that relations in this field were returning to normal.

Bystritskii's goals were to reciprocate after his U.S. visit and to provide the warmest possible atmosphere to optimize the productivity of scientific exchanges in the opening switch area. To achieve these goals, Bystritskii organized the visit outside the usual Intourist channels, a most difficult and trying enterprise at which he succeeded admirably. Among the difficulties, trials, and successes:

- Marginal, awkward, unreliable, slow, and expensive communication links: intracity, intercity, inter-region, and international.
- Hotels and airlines keep reservations and passenger lists on notebooks or loose sheets of paper (hard copy memory systems), so minor changes or additions become a nightmare and the specter of lost lists always looms.
- Frustrating demands for cooperation from a system where a concept of reward for the common man is extinct.
- Soviet visas withheld until the last minute (this appears to be a reciprocal U.S.-Soviet problem).
- The Intourist bypass involved requisition of hotel rooms by the Academy; this bypass demanded all the "blat" (influence) the Academy could muster.
- Assignment of Academy personnel to drive, guide, and lead us through a tight schedule of Institute work visits from early morning till late afternoon followed by tours to local sights. These tours lasted well into the long evening daylight hours (the sun set in Moscow and Novosibirsk at 2330, and in Leningrad it took a brief dip into the horizon [330° azimuth at 2345] reappearing in the very early morning with a weak northeasterly bearing). Darkness never interrupted the long dusk that blended into dawn and children were still playing outdoors at 0100).

Our hosts met the challenges with admirable aplomb and it was evident from the minute we landed that we were their honored guests. They were genuinely happy to have us there and did their utmost, up to the limits of their physical endurance, for us.

Observations About Everyday Life. The attention devoted by the media to recent events in the Soviet Union may have dulled Western feelings for the changes that may be taking place under the new leadership. As a liaison scientist, I feel compelled to record a few remarks that resulted from my personal observations or candid conversations with hosts, guides, and Soviet colleagues:

- The infrastructure, with the exception of the Moscow Underground, is severely decapitalized. Deferred maintenance is evident everywhere.
- The food distribution system seems to be out of touch with a country that spans ten time zones. Refrigeration is scarce (never saw a refrigerated truck or refrigerated rail car) and food conservation means (packaging, antioxidants, sequestering agents), judging from the state of goods on market shelves, appears to be primitive or nonexistent.
- A fair fraction of the population seems to spend long unproductive hours in interminable queues waiting for items that may become unavailable. The psychological, social, and economic impact of these queues must be beyond measure.
- Food shortages appear to be common, and hoarding affords some protection by offering bartering possibilities. It is also a source of instabilities that exacerbate shortages.
- Perestroika is freeing some economic structures without improving the productivity of the foundations. In some distribution systems, goods appear to enter and leave through the rear door. The prices of diverted goods are beyond the reach of the average wage earner, fueling severe inflation.
- The service sector of the economy does not function. As an example, a private vehicle damaged by an accident is a total loss unless the owner has access to foreign currency, housing priority lists, automobile priority lists, or stores that distribute Western goods. Even with such access, competent mechanics are hard to find. Humor on this sector abounds.
- Inconvertibility of the Soviet Ruble into hard currency is a source of large distortions in the economy. The disparity between the free (and illegal) market (about 8 R to $1) and the official market (0.6 R to $1) is another dormant inflation fuze that is beginning to stir.

Some Other Observations. Apparently, Chairman Gorbachov's policies have made some impact on alcohol consumption. At one time public drunkenness may have been a significant problem. Admitting that I viewed a minuscule cross section of life, both during our tours and in the excursions I took on my own, I did not witness a single case. Similarly, compared to tales I have heard from participants at previous meetings, drinking at the social functions could even be described as shy of moderate with no pressure from our hosts to engage in endless toasts.

Another interesting contrast is the absence of homeless people that are so evident in large American and European cities. I may speculate that housing, even though marginal, is available to everybody. Homelessness may be illegal or safety nets exist to prevent it.

Wherever I went, I was struck by the beauty, happiness, and healthy appearance of children. Perhaps because their freshness contrasts with what is otherwise a somewhat drab environment. I was also struck by the summer traveling crowds at train stations and airports. At 0300, a stroll across the waiting room of the Novosibirsk train station searching for a restaurant revealed an orderly crowd of perhaps a couple of thousand people waiting for connections. And, yes, a dimly lit restaurant in the basement rewarded me, for 25 kopecks, with the tastiest cabbage and sour cream soup I have ever had.

Groupe Graphique Moleculaire and Molecular Graphics Society

Dr. Alfred H. Lowrey, scientist in Laboratory for the Structure of Matter, Naval Research Laboratory, Washington, D.C.

The two meetings of groups working in Molecular Graphics in Brussels, Belgium, May 23 to 25, 1989, reflected interest in international cooperation. There is provisional agreement that Groupe Graphique Moleculaire will be associated with the International Molecular Graphics Society in a manner somewhat similar to the Molecular Graphics Society of the Americas--an organization formed at the International Meeting in San Francisco in 1988. Four themes predominated both meetings.

- There are many integrated graphical display systems of high quality being developed internationally.
- Computational aspects of this field continue to be a major driving force. In particular, the development of major network software provides access not only to common files but shared processing. The reports on these developments suggested that they will influence the continuing growth and development of graphical display centers.
- Computational database resources and developments will become major factors in Molecular Graphics. Not only are they necessary for the rapid growth of available information, but these database resources are becoming the heart of new computational and analytical techniques.
- The impact of new computational hardware continues at an undiminished rate. The new equipment available for demonstration and the projections of the experienced scientists suggest that state-of-the-art technology today has a half life of less than 2 years with factors of 10 in speed and capacity already in sight.

ONREUR REPORTS AND MAS BULLETINS

Reports

To request reports, indicate the report number (in parenthesis after the title and author's name) on the self-addressed mailer and return it to ONREUR.

Communications

NATO Advanced Workshop on Supercomputing, by J.F. Blackburn. **(9-12-C)**. The NATO Advanced Workshop on Supercomputing was held in the Norweigian Institute of Technology, June 19-23, 1989, in Trondheim, Norway. The papers presented concentrated on supercomputer architecture, programming for parallel systems, performance measurements, conversion of sequential programs to parallel programs, and applications programming. This report summarizes the following lectures:

- Supercomputing: Key Issues and Challenges, K. Neves and J. Kowalik, Boeing Computer Services, Seattle, Washington
- Supercomputing at KFA Juelich; Experiences and Applications on Cray X-MP, F. Hossfeld, Kernforschungsanlage Julich GmbH, FRG
- Supercomputing, the View from National Center for Atmospheric Research, B. Buzbee, NCAR, Boulder, Colorado
- Research and Development in the Numerical Aerodynamic Systems Program, R. Bailey, NASA Ames Research Center, Moffett Field, California
- Supercomputing Experience with Operational Parallel Processing, G. Hoffman, European Centre for Medium-Range Weather Forecasting, Reading, U.K.
- Supercomputing Environment at San Diego Supercomputer Center, S. Karin, San Diego Supercomputer Center, San Diego, California
- Architecture of Fujitsu Supercomputers, K. Uchida and K. Miura, Fujitsu America, Inc., San Jose, California
- Advanced Architecture and Technology of a Supercomputer System, T. Watanabe, NEC Corporation, Tokyo, Japan
- Suprenum, K. Solchenbach, Suprenum GmbH, Bonn, FRG
- Fast Database Systems, K. Bratbergsengen, Norweigian Institute of Technology

- Process Scheduling, H. Jordan, University of Colorado
- A Cooperative Approach to Program Optimization, L. Levesque, Pacific-Sierra Research Corp., Placerville, California
- Tools for Parallel Programs, D. Sorensen, Argonne National Laboratory, Argonne, Illinois
- Linear Algebra Library for High-Performance Computers, J. Dongarra, Argonne National Laboratory
- Maximally Parallel Task Systems, S. Kumar, Boeing Computer Services
- The Role of Workstations in Supercomputing, E. Levin, NASA Ames Research Center
- Issues in Scientific Visualization, B. McCormick, Texas A&M University
- Visualization, Engineering, Computers, and CAD, H. Santo, Technical University of Lisbon, Portugal
- SARA--A Cray Assembler Speed-Up Tool, R. Babb II, Oregon Graduate Center, Beaverton, Oregon
- Measurements of Problem-Related Performance Parameters, R. Hockney, Reading University, U.K.
- Supercomputer Performance Evaluation, J. Martin, T.J. Watson Research Center, IBM, Yorktown Heights, New York
- Information Applications on the Connection Machine, D. Waltz, Thinking Machines Corp., Cambridge, Massachusetts
- Vectorization and Parallelization of Transport Monte Carlo Methods, K. Miura, Fujitsu America, Inc.
- Super Parallel Algorithms, D. Parkinson, Active Memory Technology Ltd, and Queen Mary College, London
- Parallel and Vectorized Algorithms for Nonlinear Optimization Problems, D. Conforti, University of Calabria, Cosenza, Italy
- Large Sparse Linear Systems, I. Duff, Harwell Laboratory, Oxfordshire, U.K.
- Interconnection Networks for High-Speed Parallel Supercomputing, R. Stefanelli, Politecnico di Milano, Italy

MAS Bulletins

The following Military Applications Summary (MAS) Bulletins were published between 29 September and 31 October 1989. The MAS Bulletin is an account of accomplishments in European naval research, development, and evaluation. Request copies by number from ONREUR.

47-89 NATO Establishes Insensitive Munitions Information Center

48-89 Metal "Sprayform" Coating of Non-Conductive Structures

Reports on European Science and Technology from Other Commands

Reports

Information on each of the reports listed below was furnished by the following activity. Address requests to:

EOARD - European Office of Aerospace Research and Development, Box 14, FPO New York 09510

Applied Science

Hebrew University Applied Sciences Research, by Dr. Vince Donlan, EOARD. (11pp) [EOARD-LR-89-056]

This report describes some of the research being conducted in the research institutes and science departments at Hebrew University, Jerusalem, Israel. Topics covered are supercomputing by multiprocessing, database and knowledge management, languages for deductive and expert databases, a user-friendly SQL interface, automatic database schema design, reasoning with incomplete information, super resolution from image sequences, motion-based segmentation of 2-D scenes, attentive image resampling, pattern recognition with uncertainty, Mossbauer studies of high-temperature superconductors, and spectroscopy and properties of doped sol gel glasses.

Applied Science Research at Ben-Gurion University, Beer Sheva, Israel, by Dr. Vince Donlan, EOARD. (8pp) [EOARD-89-059]

This report describes several research programs ongoing within the Departments of Physics, Chemistry, and Electrical and Computer Engineering at Ben-Gurion University of the Negev. The topics covered are lead azide and other chemical lasers; cryptographic keys based on chaos theory; rugged, low-cost eddy current magnetometers; seeing quality in remote imaging; target

acquisition probability analysis; nonradiative energy transfer in laser hosts; and metal liquid-like films.

Chemistry

Second International Symposium on Polymer Electrolytes, Siena, Italy, by LTCOL Chet Dymek, EOARD. (14pp) [EOARD-LR-89-055]

The Second International Symposium on Polymer Electrolytes was held in Siena, Italy, June 14-16, 1989. Seven sessions progressed from fundamental studies on polymer systems, transport properties, and structure/behavior correlation, to more applied work such as testing of new electrolytes (composites, linked, new anions and cations, and solvent additives) and finally to applied work in batteries and electrochromic displays. The most widely studied systems were poly(ethyleneoxide) [PEO] and poly(propyleneoxide) [PPO] and variations thereof in combination with lithium anodes. There is still only a sketchy picture of the mechanism for conduction in these solid electrolytes. However, prototype batteries with practical conductances were reported.

Electrochemistry at Harwell Laboratories, by LTCOL Chet Dymek, EOARD. (11pp) [EOARD-LR-89-063]

Two activities involving U.S. Air Force-sponsored R&D in electrochemistry are underway at Harwell Laboratories--an expert system for corrosion control problemsolving and a research program into new high-energy and power density battery concepts. A strategy for using the expert system in the field has been developed. The facilities are outstanding where the proposed research into new battery concepts would be conducted. Harwell's Materials Engineering Center is active in the area of gas sensing and has also developed novel devices for doing micro-electrode work. The Applied Electrochemistry Center continues to find ways to enhance the performance of the Zebra type battery. Harwell also has a program in nickel-hydrogen batteries for space applications.

Composite Materials

GEC Engineering Research Center Glass/Ceramics Group, by Dr. Vince Donlan, EOARD. (28 pp) [EOARD-LR-89-049]

The Glass/Ceramics Group of the Materials Department of the GEC Engineering Research Center specializes in the research, development, and limited production of glasses, ceramics, and glass/ceramics. The range of developments includes zero expansion glass/ceramics, infrared and visible transmitting glass/ceramics, thermally matched glasses for metal-to-glass seals, and ceramic composites. This report includes Techbriefs and a reprint that describe in detail these and many other developments and capabilities of the group.

Strain Measurements Via Raman Spectroscopy to Study Compressive Behavior of Polymer Fibre-Reinforced Composites, by LCOL James G.R. Hansen, EOARD. (6 pp) [EOARD-LR-89-065]

Professor Young, Manchester, U.K., is using Raman spectroscopy to optically measure strain within polymer fibers that have outstanding tensile properties but relatively poor compressive properties. Strains in rigid-rod polymer PBT and PBO fibers have been measured both separate from and imbedded within an epoxy matrix. Understanding kinkband formation from compressive loading could lead to improved polymer fiber-reinforced composites. Raman spectroscopy strain measurements are also useful in studying the micromechanics of composites and assessing and monitoring composite processing.

Computer Science

Safety Critical Software Development Methodology at Praxis Systems PLC, by MAJ Tom Speer, EOARD. (6pp) [EOARD-LR-89-060]

Praxis Systems is a software engineering firm that specializes in the development of high-reliability software. Praxis' activities include application software development, quality management, and teaching short courses in formal methods. Praxis is experienced in applying formal methods; e.g., VDM and Z, to the specification and coding of software and integrated circuit architectures. These techniques help to uncover deficiencies in the conception and specification of the software's functions, and provide a rational means of ensuring that the software produced conforms precisely to its specification. Praxis' practical experience in applying these methods has led them to extend the methods to handle wider classes of problems; e.g., flight control system software.

Physics

Science and Engineering Research at Tel Aviv University, by Dr. Vince Donlan, EOARD. (13 pp) [EOARD-LR-89-057]

Several of the ongoing research programs within the Faculty of Exact Sciences and the Faculty of Engineering at Tel Aviv University are described in this report. Topics covered are photocathodes, InP passivation and metallization, free electron laser, optical invariant pattern recognition, high-energy density batteries, and thin film deposition.

Physics Research at the Weizmann Institute of Science, Rehovot, Israel, by Dr. Vince Donlan, EOARD. (9pp) [EOARD-LR-89-058]

Several of the ongoing research programs within the Physics and Chemistry faculties of the Weizmann Institute of Science are described in this report. Topics covered are nuclear magnetic resonance studies of ^{125}Te in $Hg_{1-x}Cd_xTe$, printed antennas, incoherent light optical correlation, optical neural networks, spectroscopic

studies of high power pulsed plasma devices, and solar-powered lasers.

High-Resolution Laser Spectroscopy at the University of Kaiserslautern, Federal Republic of Germany, by Dr. Stacey Lazdinis, EOARD. (7pp) [EOARD-LR-89-061]

The work of Professor W. Demtroder of the Department of Physics at the University of Kaiserslautern, Federal Republic of Germany, in high-resolution sub-Doppler laser spectroscopy is summarized. His application is detailed of the molecular polarization and optical double resonance spectroscopic techniques to NO_2, SO_2, Li_2 and the dimer Cs_2.

THE EMBASSIES: TECHNOLOGY ROUNDUP

Federal Republic of Germany

For further information on FRG items, contact Mr. Edward M. Malloy, Science Counselor, American Embassy, Bonn, APO New York 09080-7400.

German High-Temperature Gas Reactor THTR-300--Final Shutdown

After several weeks of grueling negotiations among representatives of the nuclear powerplant operator, the federal government, and the state government of Northrhine Westphalia (NRW), it was decided to shut down permanently the 300-megawatt (electric) thorium-fueled high-temperature gas reactor (THTR-300) at Hamm-Uentrop, NRW. This decision, together with the continued refusal of NRW state officials to license fuel loading for the Kalkar fast breeder, marks the end of advanced reactor development in the Federal Republic of Germany (FRG). It also marks the turnaround of the NRW Social Democratic Party from avid promoter of nuclear energy in the 1970s to dedicated opponent in the 1980s.

As a first-time demonstration of high-temperature gas reactor (HTGR) technology, the THTR-300 was never expected to make a profit, but rather to establish the technical basis for a successor generation of commercial-size HTGRs. Prospects for building such reactors in the FRG for the foreseeable future have dipped to zero. However, there is some hope for cooperating in the construction of HTGRs in the U.S.S.R. and China.

In addition, persistent technical problems have seriously curtailed the plant's operation. The THTR-300 has been shut down since October 1988 because 30 clamping bolts (of 2,500) were found broken, caused by embrittlement from high neutron flux. Indeed, the long construction time (12 years), the high costs ($2 billion), and the low availability resulting from technical problems may have demonstrated the reverse of what was intended. Still unresolved is how to apportion the THTR-300 decommissioning and dismantling costs among the federal and NRW-state governments and the powerplant operator.

France

For further information on French items, contact Dr. Mike Michaud, Science Counselor, American Embassy, Paris, APO New York 09777.

French 1990 Civilian R&D Budget

In a recent press conference, French Research Minister Curien presented France's 1990 civilian research and development (R&D) budget. The latter will increase by 7.1 percent (approximately F3 billion - $476 million), which confirms last year's trend (plus 7.6 percent) and is higher by two points than the rise in public expenditures. Curien's priorities are industrial research, scientific employment, and training.

According to Curien, the 1990 civilian R&D budget will enable France to come closer to its objective, which is to bring R&D expenditure to 3 percent of the GDP. However, the goal still is far from being achieved. According to the first estimates, the F45.35 billion ($7.20 billion) earmarked for research in 1990 will represent 2.38 percent of the GDP (against 2.34 in 1989). France remains far behind the Federal Republic of Germany whose budget represents 2.8 percent of the GDP, but the trend is upward. With a 7.1-percent increase in current French francs for the second consecutive year, the R&D budget makes good on the promises of both President Mitterrand and Prime Minister Rocard who consider R&D as a priority long-term investment. The major part of the civilian R&D budget (53 percent) will go to the major public research institutions, which is a 5.8-percent increase.

According to Curien, R&D expenditures in companies remain insufficient, which is the main handicap compared with France's competitors. Curien indicated that it was therefore necessary to reinforce governmental action. In view of this, financial support of industrial R&D will increase the most (by 19.4 percent). Nearly F5 billion ($794 million) will be allocated, of which F1.566 billion ($261 million) (plus 30 percent) is for the research and technology fund. The purpose of the fund is to encourage technology transfer through financial incentives and to support the major national programs.

Small- and medium-sized firms will receive additional support through Agence Nationale Pour la Valorisation de la Recherche - National Agency for the Exploitation of Research (ANVAR) and the French Industry Ministry. The ANVAR's allocation has been raised to F845 million ($234 million), which represents a 10-percent increase. These firms will also receive F843 million ($134 million) from the Industry Ministry for the financing of major innovative projects and for certain projects in the electronic sector. Finally, the so-called research tax credit is improved. The research tax credit is a tax measure that consists of deducting taxes by an amount equal to 50 percent of the yearly increase in R&D expenditure.

The allocation of the so-called grands programmes (large programs), which represents 36 percent of the budget, will increase by 5.6 percent. The large programs concern sectors of major importance requiring long-term investments. There are four such large civilian programs--aeronautics, space, telecommunications, and nuclear. The main beneficiary is aeronautics that will receive F2,883 million ($458 million), representing a 17-percent increase. Space will receive F7,187 million ($1,141 million), which represents an 11-percent increase. This will help finance the Spot IV Earth Observation Program as well as pursue European programs (Ariane V, HERMES, and Columbus). However, the allocation of the Atomic Energy Commission (CEA) will decrease by 4 percent (F6,284 million [$997 million]) and is a result of the freeze on the nuclear program. Curien indicated that he intends (in conjunction with Industry Minister Fauroux) to redefine the missions of CEA.

Research Minister Curien identified three other priority areas that do not fall into any of the above categories:

- Environmental and atmospheric research - 13-percent increase for the Ministry of Environment, and 30-percent increase for the National Meteorology Agency
- AIDS research - F180 million ($29 million), representing a 20-percent increase (in addition to the funds earmarked for such research out of their own budgets by INSERM, CNRS, and the Pasteur Institute)
- Training in engineering schools through research.

Italy

For further information on Italian items, contact Gerald Whitman, Office of Science Counselor, American Embassy, Rome, APO New York 09794-9500.

Italy--Technology Roundup

Verona to be Site of European Institute of Technology. The European Institute of Technology (EIT), founded in February 1988 and sponsored by AT&T, ENICHEM, IBM Europe, Montedison, and Philips will be located in Verona, Italy. The EIT, created as a point of contact between European private industry and the university research community, will offer short courses, summer workshops, and a program leading to a Masters Degree in Technology Management. For its first activity, EIT is providing funds for 35 research projects in biotechnology/pharmacology, information technology, and materials technology.

National Institute of Nuclear Physics Receives Financing for Research Facilities. The National Institute of Nuclear Physics received 1,800 billion lire (about $1.3 billion) from the government for 1989-1993. About 1,000 billion will be used to improve the 19 sections of the institute (located in as many universities) and to develop research in the institute's four national laboratories. A new particle accelerator will be developed in Frascati, costing 80 billion lire. Named Ares, this accelerator will attain one billion electrovolts and be used to develop radio frequency and superconductivity technologies. The Gran SASSO Laboratory will get 200 billion lire for new equipment, while 20 billion each will go to the Padua Accelerator and to the new Cyclotron in Catania. The Geneva large electron-positron collider project will receive 30 billion lire.

Laboratory of Cosmic Physics Inaugurated in Naples. The Italian Space Agency inaugurated a cosmic physics laboratory in Naples with the support of several universities and astronomical and geophysical observatories. The laboratory will study new sophisticated techniques to analyze extraterrestrial matter from meteorites. Efforts will concentrate in studying cosmic sand suspended in space and creating molecules containing carbonium. This study could be the first step in creating living matter.

Trieste Research Area Plans Intelligent Systems Institute. An advanced institute for human brain studies will be established in the Trieste research area. Professor Emilio Bizzi, Department of Brain and Cognitive Sciences Director at MIT, will direct the new institute.

SERONO Institute Produces Human Growth Hormone. The SERONO Institute of Pharmacological Research announced it had produced through genetic engineering a human growth hormone, the absence of which causes dwarfism. The product is obtained by inserting the gene of the protein to be fabricated into the DNA of a mammal cell, which then synthesizes the protein. Therapy for dwarfism can now rely on an unlimited quantity of pure product rather than depending on small quantities obtained from cellular extraction.

Ultraviolet Laser Light Employed in Arteriosclerosis Therapy. Researchers at the University of Florence and at the Italian National Research Council's Institute of

Quantum Physics (with the technical support of the electronic company, Elen) have built a device employing strong intensity ultraviolet laser light to destroy plaques that are obstructing arteries. This method for no-pain therapy costs 3 billion lire (about $2.2 million) and is similar to devices developed in Los Angeles, Berlin, and Paris.

FIDIA Signs Research Cooperative Agreement with U.S.S.R. An Italian pharmaceutical company, FIDIA, is building an institute for research on new therapeutic drugs for nervous system pathologies in Moscow under an agreement with the Soviet Academy of Sciences. Known as the FIDIA-ALL Union Neurosciences Laboratories, the institute will develop research programs in new growth factors based on the work of Nobel Laureate Rita Levi-Montalcini. The institute carries on similar research in its U.S.-based laboratory and plans to sponsor researcher training and exchanges with the U.S. and the U.S.S.R.

Italy and China Build Laboratory on Everest. The Italian Research Council, in cooperation with the Chinese Academy of Sciences, is installing an aluminum pyramid to house experiments in astronomy, gravity, geodesy, and geology on Mount Everest. Several Italian universities will participate in the program. Located at 5,600 meters altitude, the pyramid has a 187- square meter base, is 8.4 meter high, and will house 20 researchers.

Italy Building Renewable Energies Laboratory for Egypt. Ansaldo's Center for Energy Studies, in conjunction with Egypt's New and Renewable Energy Authority, will construct a renewable energies laboratory in Cairo to study solar, wind, photovoltaic, and biomass energy sources. The 2-billion lire contract (about $1.5 million), is part of a 21-billion lire European Economic Community project for Egypt. Italian technicians and expertise will be provided to establish an alternative energies policy for new urban and industrial settlements in the desert.

Italian Robot Exports Surpass Imports. In 1988, Italian industry imported 345 robots (out of 2,262) from abroad. During the same period, Italy exported 650 robots with a net gain of 60 billion lire (about $44 million). Also during 1988, Italy moved from fifth to fourth place in the world of production and export, gaining a 7.2-percent share of the world market. The Italian National Research Council hopes to make Italian robots still more competitive through its robotics research project with an investment of 68 billion lire (about $50 million) over 5 years.

Genoa's Research Consortium. The City of Genoa's research consortium supports small and medium industry of the Liguria region. The consortium comprises more than 20 laboratories and research centers, employing about 300 technicians and researchers. In addition, the consortium offers services in several industrial areas, including mechanics, electronics, chemicals, metallurgy, biology, and building sciences. A well-equipped CAD center is available, plus access to several data banks that link the consortium to the major research centers in Europe, the U.S., and Japan.

Yugoslavia

For further information on Yugoslavia items, contact Thomas Vrebalovich, Science Counselor, American Embassy, Belgrade, APO New York 09213.

Global Environmental Issues at Nonaligned Movement Summit

Yugoslav hosts and other participants in the recently concluded summit of the nonaligned movement in Belgrade produced a summary of their positions concerning the future course of negotiations and work on global environmental issues. The statement notes that participating heads of state or government "were greatly concerned at the continuing deterioration in the State of the Environment." The statement also expressed the "readiness of non-aligned countries to intensify and promote international cooperation in the area of environmental protection in order to prevent the disruption of the global ecological balance." Water and air pollution, depletion of the ozone layer, soil degradation, and deforestation are the primary areas of concern.

In their statement, the summit participants implicitly discuss both these international agreements. They said that international measures to control using environmentally damaging substances should be aimed at readdressing the existing asymmetry in world consumption and production levels. Regulatory regimes that seek to subject production and consumption of certain substances to international control limits must help developing countries adjust to new standards. Summit participants recommend that a special international fund be created to promote international cooperation to finance environmental research and development of alternative technologies. The technologies can then be affordable by developing countries.

The nonaligned summit participants called for adopting effective international measures to prohibit exporting toxic and other hazardous wastes in the territories of other (especially developing) countries. They pledged to maximize the benefits from the existing "dump watch" to facilitate sharing information on the activities of, and clandestine routes traversed by, merchants of toxic and other hazardous wastes. They also proposed that, in the meantime, the developed countries should adopt rigorous administrative measures and legislation to ban this exporting.

With serious concern, they noted that changing global climate patterns threaten present and future generations

with severe economic and social consequences. Necessary and timely action should be taken to deal with climate changes and their consequences within a global framework. In this context, they called for preparation and adoption of an urgent international convention on protecting and conservating the global climate.

The nonaligned movement summit participants support both the proposed 1992 United Nations conference of environment and development, and the Brazil's offer to host it. They recommended convening a special ministerial coordinating meeting of the nonaligned and other developing countries before the conference.

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